Sectional Volume No. 1.

Ministry of Agriculture and Fisheries.

COLLECTED LEAFLETS

ON

FUNGUS PESTS

OF

FRUIT TREES

(THIRD EDITION.)

LONDON:
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INTRODUCTION.

Unlike insect pests, which are for the most part more or less clearly understood, there is often a certain mystery in the public mind connected with fungi. Their strange form, sudden appearance and devastating habits are not readily explainable. To the practical fruit grower painful familiarity with their presence soon robs fungus parasites of any mysterious charm, and, by force of circumstances, he is compelled to study them, if it be only their mode of attacking plants and the best methods of keeping them at bay. Whether, however, the origin and habits are understood or not, it may not be inadvisable to point out at the commencement of this volume the main outlines of the life of any ordinary fungus.

The Nature of Fungi.—The fungi consist of a group of organisms belonging to the vegetable kingdom. In common with bacteria, fungi differ from all other members of that kingdom in that they possess no green colouring matter (or *chlorophyll*) and are therefore unable to obtain their carbon food supply from the air as do ordinary flowering plants. This accounts for their peculiar habitats, fungi being found on materials derived from dead plant or animal tissues or on the living organisms themselves. In size they vary greatly; some are large, but the majority are minute. Those which cause serious epidemics amongst crops are usually amongst the smaller species. Each fungus consists essentially of two parts: (1) a system of fine threads, technically called the mycelium, and (2) spores, which correspond to seeds in ordinary plants.

Mycelium.—It is well that growers should be clear as to the term mycelium, especially as no English equivalent is available. In a large earth-growing species such as the mushroom it consists of the white threads or "spawn," and a similar kind of mycelium can be found in any of the toadstools or puffballs. The mycelium absorbs nourishment from the substance in which it grows—soil, wood or humus—and in the case of a parasitic species it extracts this food at the expense of the host-plant and causes more or less definite injury. In the smaller fungi the mycelium, though very minute, is similar in form and has the same function as in the larger species typified by the mushroom. In mildews and certain moulds it exists on the surface of the host and may be seen with the aid of a lens as a loose, cobwebby growth. In others it is internal, or located within the host, and only shows itself after the damage it occasions is completed.

Spores.—It is equally important to know something of the nature and significance of the spores. They serve to propagate

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the species and, although produced in enormous numbers, are always very minute. In the larger fungi they are borne on an elaborate cap-shaped structure, *e.g.*, the cap or edible portion of a mushroom. Anyone can demonstrate the vast quantity of spores which are produced by a mushroom by cutting off the stalk and laying the cap, gills downward, for a few hours on a plate or piece of white paper and covering with a tumbler. A copious fall of spores will be found and an outline of the gills will be seen on the paper. If the cap is not covered only a few spores will be deposited owing to their being blown away as they fall by draughts.

Precisely the same spore-discharge takes place daily in orchards and gardens. Silently and unobserved, fungi both large and small, are, if the weather be favourable, discharging myriads of dust-like spores. Most of these are wafted as a totally invisible dust over neighbouring plants or neighbouring fields; some may be blown away in bulk, others washed down by rain. The big toadstool may discharge its hundred millions, the Coral Spot fungus its one million, but in all fungi, when the reproductive phase is reached, an exceedingly copious crop of spores is developed.

When it is remembered that this spore-discharge takes place all over the country and that, borne by the breeze, spores are rained on every garden, field and orchard, the sudden appearance and rapid spread of a mildew like American Gooseberry Mildew or a tree disease like Silver Leaf is no longer mysterious. The wonder is that fungus epidemics are not more prevalent and that, relatively speaking, so very few spores fulfil the function for which they were produced.

Saprophytes and Parasites.—As is the case with seeds, spores germinate under suitable conditions of warmth and moisture. Each spore gives rise to fresh mycelium and thus produces a new plant. Whether this infant fungus will grow and mature depends on the nature of the substratum. Fungi differ enormously in their requirements. Some are so adaptable that they can flourish almost anywhere where moisture and vegetable matter of any kind are present. Others have a more restricted range, requiring either leaf mould, dead wood or rotten fruit as the case may be. Yet others show a decided tendency to feed on living organisms and thus pass from the realm of harmless saprophytes (*i.e.*, organisms that live on dead organic matter) to that of parasites.

Types of Parasitic Species.—As far as the present volume is concerned, the interest lies wholly with the parasitic species. These show varying degrees of parasitism and, for this and other reasons, there is considerable diversity in the amount of damage they cause. There are the feebly parasitic fungi which occur abundantly on dead shoots, but under certain conditions spread into the living tree and cause damage. Amongst species of this class attacking fruit trees Coral Spot is a good example. Others, although they commence on a dead branch or wounded

area, become more readily and seriously parasitic and will, unless checked, invariably proceed rapidly in the living tissues and occasion much damage. This form of parasitism, in various degrees of intensity, is seen in the following diseases of fruit-trees:—Brown-Rots, Die-Back of Plums, Apple Canker and Silver Leaf. Lastly, there are the exclusively parasitic forms of which it may be said, in a general way, that their power to bring about the infection of sound, uninjured tissue is confined to the leaf-attacking species, which are found principally in three natural groups, the rusts, the mildews and the false mildews. Alighting on a leaf, the moisture provided by a light dew allows the spores to germinate and the germ tube of the spore rapidly enters the leaf, either through the stomata (or breathing pores) or by piercing its way through the epidermis or outer skin of the leaf. The true rusts (such as Plum Rust), the false mildews (few of which attack fruit) and the Apple and Pear Scab fungi effect an entrance in this way. The true mildews, such as American Gooseberry Mildew and Apple Mildew, are highly parasitic but differ from other fungi in being superficial and extract all their nourishment by means of minute suckers which penetrate the epidermal cells. The damage that mildews cause, however, is very severe.

Mode of Attack and Measures of Control.—The method of attack, subsequent development and above all the means of hibernation of fungus parasites are, from the practical standpoint, of very great importance and should be mastered by every fruit grower. In the leaflets a short outline is given in each case, but a very brief summary is added below, the diseases being grouped according to the nature of the damage caused. An indication of the type of treatment required is also stated.

(*a*) *Fungi attacking the Leaves.*—Leaf fungi, though comprising many forms, are usually combatted by spraying or dusting. Spraying may aim at the prevention of an attack or, more rarely, at the destruction of the mycelium and spores. If the leaves are covered with a film of fungicide, the slender germ tube which the spore produces on germination is killed and infection does not take place. The action of the spray here is preventive. To mildews, the mycelium of which is superficial, a spray or powder may be applied with the object of the actual killing of the mycelium. This is often largely successful, but, even with mildews a *preventive* spray is more effective and should always be employed if possible.

The method of hibernation varies considerably. Where this is known it is often possible almost to exterminate the fungus by the removal of the winter stage. In mildews the normal method of hibernation is by means of resting spores contained in spore-cases produced on the old mildew patches either on the leaves or shoots. The affected leaves and shoots

in this case should be collected and destroyed. The operation of tipping for American Gooseberry Mildew has this object in view. In some mildews, *e.g.*, Apple Mildew, few or no resting spores are formed and the mycelium hibernates in the buds and develops with them in spring. In this case affected buds should be cut out.

In most other leaf-fungi winter or resting spores form in the old leaves, hence the invariable advice of the mycologist to burn affected foliage. It is now known, however, that leaf-fungi not infrequently also attack the young wood and pass the winter on twigs on the tree. Apple and Pear Scab are the best known and most striking examples of this form of hibernation, and the great importance of *removing scab-infected wood* is now recognised by all up-to-date growers.

(*b*) *Fungi attacking the Fruit.*—The most destructive fungi of this group are those causing the Brown Rots of pear, apple, plum, cherry and other stone fruits. In these diseases the fungus remains in the attacked fruit and, drying them up, forms the well-known mummies which hang on the trees during winter. The mycelium hibernates in the mummies, becomes active the following season and liberates spores. In addition to spore-infection the inoculation of new fruit is also brought about if the latter is in direct contact with a mummy as is often the case when fruit is borne on spurs. An important point to remember, however, is that Brown Rot fungi also attack flowers and shoots, forming Blossom-Wilt, Wither-tip and Canker, and that when the shoots are infected the fungus hibernates in them also. In each of the Brown Rot diseases, therefore, attention should be concentrated on removing not only mummies, but all wood that has been killed by Brown Rot the previous season.

Apple and Pear Scab are only second in importance to the Brown Rots. The scab fungus hibernates on the wood and passes from this to the leaves. From the leaves it spreads to the young fruit. A somewhat similar method is found with the less prevalent diseases Bitter Rot and Black Rot of apples.

(*c*) *Fungi attacking the Wood.*—This group is connected with the last by the Brown Rot and Scab fungi which at times seriously injure the wood of both plums and apples. The fungi particularly in view under the present heading are, however, those which attack the wood only, and these invariably gain entrance through a wounded surface or an area of dead tissue such as a twig or broken branch. The most important fungi of this group are those causing Canker, Silver Leaf, Die-Back of plum, although there are many others.

In all these diseases the first point to ascertain is the manner in which the fungus gains entrance to the tree. Any wound may probably serve, but in ordinary orchard conditions there are generally particular injuries which act as weak points in the armour of the tree. As an instance, Apple Canker may

be taken. It has long been known that pruning and other wounds are liable to admit the canker fungus, but quite recently it has been shown that the ordinary leaf scars offer a particularly easy mode of entrance and that in certain seasons at any rate the majority of infections arise in this way. The discovery in itself is not consoling, but it points out an unsuspected weak spot and the efforts of scientific workers must now be concentrated on devising a new method of control. In the case of Silver Leaf it is known that the spores, if placed on a snag or large wound, readily bring about infection, but it is not impossible that further research will indicate additional or unperceived doors of entry.

A group of fungi which, since they invade the wood of the plant and require dead or injured tissue to gain admittance, may be included in this section, are the root fungi. The most important of these is the Honey Fungus which sometimes attacks apples. Damage in fruit trees by root fungi in England is, however, insignificant, and need not be further considered here.

The principal measures for combating the attacks of wood-destroying fungi are three: (1) *The removal of the sources of infection*, viz., dead or infected wood which, by a constant liberation of spores, is a continual menace. This includes diseased or dead wood on the tree or dead wood lying about in the orchard. (2) *The prevention of injury and the protection of wounds.* Damage through neglect should be reduced to a minimum, pruning being carefully carried out and broken branches sawn off with a clean cut. The most important item under this heading is the protection of all injured surfaces with a coat of tar or good paint which, in the case of larger wounds, should be renewed after three months. (3) *The prompt use of the knife.* Affected shoots or diseased areas should be cut out as soon as infection is apparent. By this method large branches or even whole trees may often be saved. The excised area should not be larger than necessary, but must extend to healthy wood. The wound must, of course, be protected at once by tar.

The foregoing are merely general recommendations. To be successful it is obvious that the particular habits of each fungus should be understood thoroughly. No apology, therefore, need be made for inserting paragraphs on the life-history of the parasite in leaflets intended for the practical grower.

Methods of Cultivation and the Use of Resistant Varieties.—In urging the importance of the knowledge of the life-history of fungi and recommending such measures of control as spraying and dusting, the supreme importance of good all-round cultivation has not been overlooked. This lies at the very foundation of successful fruit-growing. Scientific

method should be employed in all cultural operations of pruning, choice of soils, fertilisers, stocks and the like, just as it should be in the destruction of pests. All these cultural factors immensely affect the incidence of disease, and every mycologist would admit that sound cultivation does more than anything else to reduce outbreaks. Approved methods of culture for fruit trees will be found in Sectional Volume No. 4 (*Fruit Cultivation*), to be published shortly.

One of the chief weapons of this nature at the disposal of the grower is the use of disease-resistant varieties. The breeding and raising of new varieties is a slower process with fruit trees than with many other crops, but with the large number of varieties already in existence much may be done by judicious selection. In substituting resistant varieties for those previously grown, it is first of all necessary to ascertain whether they are suited to the soil and climate of the district. This being assured their employment in the orchard will not only save endless labour but may mean the difference between success and failure. In most of the leaflets notes are given on the relative susceptibility of varieties. It is sometimes found, however, that when good growth and resistance to the disease in question have been obtained, the variety suddenly falls a victim to another pest. Early and prompt attention is then essential and if given will often prevent the new fungus from becoming firmly established.

In spite of the very best culture and the most suitable varieties certain diseases invariably appear, and it is here that the most accurate knowlege and the most recent results of scientific inquiry will be of most value. No disease has yet been exhaustively investigated, and it is only by further research that the many problems can be solved and effective measures of control discovered.

A. D. COTTON.

London, S.W.1.

October, 1921.

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APPLE CANKER.

(*Nectria galligena.*)

Apple canker is one of the most destructive diseases with which fruit growers have to contend. It is a serious menace to fruit trees on the continent of Europe, whilst in England it has ruined many a plantation and placed certain kinds of apples very largely outside the pale of commercial cultivation. Though the term canker is often applied to various open wounds where the bark is swollen and rugged, the true apple canker, as understood in Britain, is a specific disease, and is caused by the minute fungus *Nectria galligena.** The same fungus also causes canker in the pear.

Description.—The general appearance of apple canker will be recognised from the figures accompanying this leaflet. Fig. 1 represents an early stage of the disease, Fig. 2 one which is far advanced. Cankers may occur anywhere on the branches, but they are found most frequently at a node or at the junction of a small branch with a larger one.

The beginning of the canker-wound and the various stages which follow may readily be observed if a diseased tree is studied with a little care. The young stages will be seen as small depressed areas of bark, which gradually break away from the surrounding part of the shoot and are somewhat darker in hue. Such areas very frequently originate at a leaf scar or around the base of a dead twig (Fig. 1), and are caused by the activity of the fungus which has gained an entrance to the tissues. This small damaged area increases in size and usually becomes more or less elongated in shape. The tissue in the central portion dies and gradually decays, so that the damaged area assumes the form of an open wound surrounded in later stages by rugged bark. Such wounds, termed canker by gardeners, are found in many plants and may be produced by a variety of causes. In the apple, canker is due to the fungus *Nectria galligena*, although, as explained below, the injury caused by Woolly Aphis is often very similar in appearance, and in fact the two pests are not infrequently found together and supplement each other in the damage they cause. One of the most marked features of apple canker is the presence of more or less regular concentric rings around the wound, and true canker may frequently be recognised by these even in the absence of the fruits of the fungus.

As the disease progresses the wound enlarges and a mass of swollen tissue, due to the repeated formation of callus by the branch, arises around it. The subsequent behaviour varies under different circumstances and with different varieties of apple. In many cases the wound is confined to

* Recent investigations show that *Nectria galligena* and not *N. ditissima* as formerly supposed, is the correct name for this fungus.

one side of the branch and the latter continues to live for many years. In other cases the parasite " rings," that is completely encircles, the branch or shoot, as shown in Fig. 2, and causes its death. Provided the branch is not ringed the sap continues to flow, and such branches remain alive and may even grow and yield heavy crops of small fruit.

The fruiting bodies of the fungus, by which alone the disease can be identified with absolute certainty, are minute and occur especially in autumn and spring. They are of two kinds. Those formed in spring and early summer are perhaps the best known. They occur on various parts of the bark around the wound and consist of round, rather tough bodies (perithecia), deep crimson in colour and about the size of a poppy seed. Large numbers of two-celled spores are liberated from these fruit-bodies and are conveyed by rain, wind, insects, &c., to other trees, and thus spread the disease. In late summer and autumn especially the fungus develops another form of fruit, which shows as whitish, minute pustules. These fruiting bodies bear externally masses of sickle-shaped spores (conidia) which also serve to spread the disease.

Causes Leading to Attack.—The canker fungus gains entrance to a tree by means of wounds or small injuries. The wounds may be large, such as those caused by breakages, careless pruning, &c., but minute injuries, especially those occurring naturally in the region of the buds, provide a very efficient means of entry. Recent work at Long Ashton shows that the leaf-scars left by the fall of the leaves in the autumn afford an excellent opportunity for the fungus to enter the tree, and, during the winter and following spring, examples of this type of infection of the previous year's shoots can be found in almost every orchard. Other wounds which may frequently lead to canker are frost cracks and the breaking of young shoots due to careless picking or pruning. The " heading back " of badly grown trees exposes large cut surfaces to infection, and main branches of trees treated in this manner are often found to be severely attacked by canker.

Another, and very important, means of entry is through injuries caused by Woolly Aphis.* The soft swollen tissue produced by the Aphis is very apt to become cracked during the autumn, exposing the woody tissues of the stem. The fungus quickly infects such splits, and infections of this type are quite commonly found on the young wood during the winter. One other method by which the canker fungus attacks the tree must be mentioned. The scab fungus towards the autumn often attacks the young shoots formed during the summer, resulting in the formation of numerous scars on the stem. (*See* Leaflet No. 131, *Apple and Pear Scab.*) These

* See Leaflet No. 34, *The Woolly Aphid*, included in Sectional Volume No. 2, " *Insect Pests of Fruit Trees*," price 10d., post free.

1.

2.

APPLE CANKER.

FIG. 1.—Young branch of Apple with a small canker present on the right-hand side. The beginning of the wound is at the base of short side shoot.

FIG. 2.—Older branch. The fungus here has not merely destroyed the tissues on one side of the branch, but has completely encircled and killed it.

scars frequently allow the entrance of the canker fungus, which causes much more serious damage than the superficial injury of the scab fungus.

Influence of the Soil.—Although the presence of wounds is so important for successful infection by the fungus, there are other factors intimately concerned with the development and prevalence of canker. Chief among these is the question of location and soil. A variety which cankers in one district may remain comparatively free in another. Canker is always worse on a low site and a clay subsoil, so much so that it is often impossible in such positions to grow certain varieties of apples successfully (*e.g.*, Lord Suffield, and Cox's Orange Pippin). The effect of damp, heavy soil is to cause rank growth, which probably permits the fungus not only to infect more readily but also to develop more rapidly in the tissues. Although a hill slope and more open soil are desirable much good may be done, where a bad sub-soil is present, by careful drainage and by the encouragement of surface rooting. With improved conditions affected trees will sometimes grow out of canker, and by careful pruning, clean, healthy trees may be produced.

Susceptibility of Varieties.—Another factor of great importance is the nature of the variety, some sorts being exceedingly liable to the disease, whilst others are more resistant. Varieties such as Lord Suffield and Cox's Orange Pippin are so prone to attack that they are liable to canker even on good soil, whilst Bramley's Seedling is resistant and will often remain free even when grown on heavy land. The following varieties are amongst those which under most conditions are subject to attack:—

Cox's Orange Pippin.
Dumelow's Seedling (Wellington).
Ecklinville Seedling.
Lady Henniker.
Lord Derby.
Lord Suffield.
Peasgood's Nonsuch.
Pott's Seedling.
Ribston Pippin.
Stirling Castle.
Warner's King.
White Transparent.
Worcester Pearmain.

Amongst the varieties usually less susceptible may be mentioned:—

Annie Elizabeth.
Beauty of Kent.
Blenheim Orange.
Bismarck.
Bramley's Seedling.
Lane's Prince Albert.
Mr. Gladstone.
Newton Wonder.

Measures of Control.—1. *Cutting-out of Diseased Wood.*—Old and badly-diseased trees should be cut down and burned. An exception to this rule may be made if, as occasionally happens, the trees are bearing well. In the case of trees not so badly diseased, cankered shoots and badly-cankered boughs should be cut out. If a sharp look-out be kept for the beginning of the canker, affected branches may sometimes be removed without much loss of symmetry to the tree. During winter-pruning all infected small shoots should be carefully removed.

In the case of large boughs the canker-patch can sometimes be cut out with a sharp knife or chisel. If care be taken to cut down well into sound wood, and to protect the exposed surface, the wound may completely heal over, and the bough may thus be saved.

2. *Protection of Wounds.*—All cut surfaces should be covered by a protective substance, such as coal-tar, Stockholm tar, paint, painters' knotting, styptic or grafting wax. If nothing better is procurable the surface may be luted with clay. Rubbing over the surface with earth, a frequent custom, should not be practised.

3. *Top Grafting.*—In certain cases, especially where the variety is very susceptible, the tree may be cut back and top-grafted with a more resistant variety, such as Bramley's Seedling.

4. *Prevention of Woolly Aphis.*—Woolly Aphis, which not only itself injures the tree, but also frequently favours infection by the canker fungus, should be kept down. Instructions as to this pest will be found in Leaflet No. 34.*

5. *Drainage.*—Apples are more liable to canker in heavy subsoils and in damp situations. Where a wet, heavy soil is present an effort should be made to drain it. In the case of young trees growing down into an unsuitable soil, the trees should be root pruned, and surface-rooting encouraged. On exceptionally heavy and stiff land trees may sometimes be planted on the surface and earthed up.

6. *Selection of Varieties.*—When planting a new garden or orchard, varieties resistant to canker, and those which have been found to do well in the locality, should be chosen.

7. *Sanitation.*—Spraying is practically useless, but in order to reduce liability to infection all general sanitary measures should be adopted, and diseased shoots and prunings should be burned.

Sale of Affected Trees.—The sale of any trees which are substantially attacked by this disease is prohibited by the Sale of Diseased Plants Order of 1922, under penalty of £10. Further information on this subject may be obtained on application to the Ministry.

APPLE AND PEAR SCAB.

(Venturia inæqualis, and V. pirina.)

Scab is probably the most general and most widely distributed fungus disease which attacks apples and pears. The well-known black blotches or scabs on the fruit caused by this fungus are familiar to everyone (Figs. 1 and 2).†

* This leaflet is included in Sectional Volume No. 2, "*Insect Pests of Fruit Trees*," price 10d.

† The Ministry are indebted to Mr. E. S. Salmon for permission to use Figures 2, 3 and 4. For more detailed description of the scab fungus *see* Mr. Salmon's article in the *Jour. Board Agric.* (Vol. XV, 1908-9, pp. 182-195).

In this country the disease causes an enormous amount of damage in apple orchards and plantations, the annual losses amounting to many thousands of pounds. During certain seasons entire crops are much depreciated in value and even rendered unsaleable. Scab is a disease, however, which can be well controlled if growers will carry out the necessary spraying treatment.

Although the fungi causing apple and pear scab respectively are different species they are very closely allied. The general appearance and method of treatment are the same in each case so that separate descriptions of the two diseases are unnecessary.

Description.—*On the Leaves.*—The first active stages of the fungus-attack appear on the leaves during the early spring. The general appearance at this stage varies according to the variety; in every case the part of the leaf which actually bears the fungus becomes a dark olive-green or sooty colour. Sometimes the fungus confines its attack almost entirely to the veins of the leaf, while in other cases it forms distinct and sharply marked patches scattered over the surfaces (Fig. 3). The spores, which are produced on these dark patches in enormous numbers, are distributed by air currents, and in this way spread the infection to other leaves, young fruit and also new wood. *It is most important to remember that the early infection of the fruit takes place almost entirely from the leaves, hence unless these are kept healthy a clean crop cannot be expected.*

On the Fruit.—Figure 1 depicts the disease as it occurs on the fruit. The spores alighting on the fruit germinate and the fungus then penetrates the skin, beneath which a mass of fungus tissue or mycelium is developed. This does not, however, grow deeply into the flesh of the fruit, but spreads immediately beneath the surface. In course of time the covering skin of the fruit is broken, with the result that thousands of dark coloured spores escape from the open wound or scab. At the margin of the scab the silvery fragments of broken skin may often be seen. The extent and nature of the injury depend largely on the date of infection and the variety of apple or pear. When attacked quite young the fruits are often much distorted and may even be injured to such an extent that they fall off. In other cases, especially with pears, more or less severe cracking takes place (Fig. 2). If the attack occurs late in the season the fungus does not make so much headway, small scabs or spots only being formed.

The spores produced on the fruit, as in the case of those formed on the leaves and wood, may infect leaves, young twigs, or other fruit. From this it will be noted that the fruits of apples and pears are subject to infection right through the growing season. Susceptibility to fresh infection ceases

when the growth is completed and the fruits are picked and stored.

On the Wood.—For many years the manner in which the scab fungus lived through the winter in this country was not fully understood. The matter has, however, been carefully investigated at Wye College and it has been clearly established that the fungus passes the winter in a dormant condition on the young wood of many varieties of apples and pears. *These diseased shoots are perhaps the main source of the initial infections the following season.* Affected wood is readily distinguished by its rough blistered appearance (Fig. 4) due to the formation of numerous small cushion-like growths of mycelium, just beneath the bark. These cushions remain dormant during the winter. As soon as the spring arrives they recommence growth and finally liberate thousands of spores which infect the young leaves and thus start afresh the life-cycle of the fungus. The infected wood varies considerably in appearance with the variety of apple or pear, the blisters being large or small, scattered as in Cox's Orange Pippin (Fig. 4), or crowded together, as is often the case with Lord Suffield. So far as is possible this scab-infected wood should be cut out when pruning the trees in winter.

The fungus is probably capable of existing in the wood of most varieties of apples and pears, but it is known to occur plentifully on the following:—

Apples.—Cox's Orange Pippin, Cox's Pomona, Ecklinville Seedling, James Grieve, Lord Suffield, Warner's King, Wellington, White Transparent, Worcester Pearmain, Yellow Ingestre.

Pears.—Beurré Bose, Beurré Diel, Clapp's Favourite, Doyenné Boussoch, Doyenné du Comice, Jargonelle, Le Lectier, Marie Louise, Pitmaston Duchess, St. Germain.

The young wood of Cox's Orange Pippin and Lord Suffield amongst apples is often severely crippled by scab, but on other varieties the occurrence of this stage of the disease is to be dreaded more from the spring-infections which it causes than from any actual damage to the wood.

On Fallen Dead Leaves.—In certain countries outside of Britain, a second form of fructification of the fungi which cause Apple and Pear Scab has been known for some time. This develops in the tissues of the infected fallen leaves during the autumn and winter in the form of minute, flask-shaped conceptacles, within which two-celled spores are produced in little sacs. In spring, these spores are actively ejected from the conceptacles, and, on being carried by air currents or other means to the newly expanding leaves, infect the latter with the disease. Although it is now clear that such conceptacles were observed in England many years ago, it was not then recognised that they belonged to the Scab

APPLE AND PEAR SCAB.

FIG. 1 (*above*).—Affected apple showing scabs.

FIG. 2 (*below*).—Affected pears. The fruits are badly scabbed and as a result are cracked and deformed. The black blotches on the leaf indicate infection of the leaves from which the fungus spreads to the fruit.

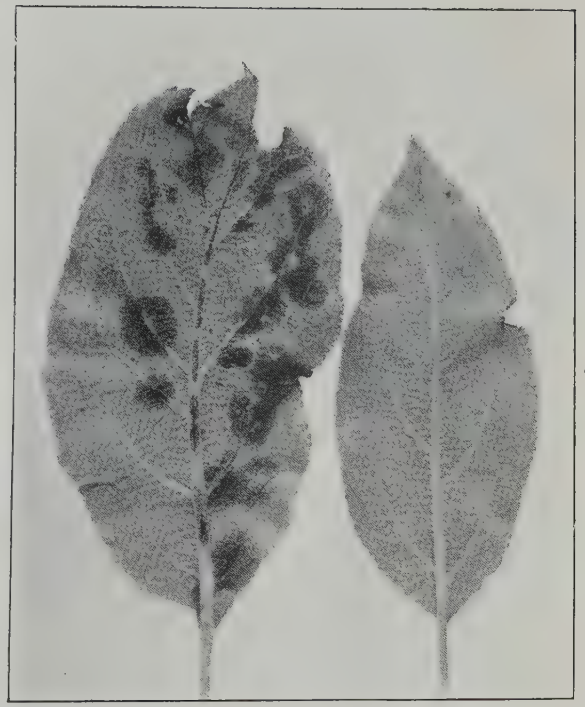

Fig. 3.– Affected apple leaves.

Fig. 4.—Young wood infected by the scab fungus A. Cox's Orange Pippin (a) healthy wood, (b) diseased wood. B. Wellington (c) healthy wood, (d) diseased wood.

fungus. Quite recently, however, these fructifications have been re-discovered and identified by the plant pathologists of Wye College. They were found in large numbers on fallen leaves of apple and pear which had not decayed during the winter. If the development of these winter fructifications should prove to be no uncommon thing in this country, it is clear that an important source of early spring infection, in addition to that connected with diseased wood described above, has been overlooked in the past.

Nature of Damage.—In addition to the loss due to cracked and deformed fruit and to the disfigurement of less infected specimens, apple scab causes a considerable amount of damage in a way less familiar perhaps to many growers. Scabbed fruits keep badly. They shrivel and in many cases, owing to the growth of moulds and other fungi entering through the scab wounds, they rapidly decay. Once a fruit becomes rotten any sound specimens in contact with it become similarly affected. In this way considerable loss in storage may be incurred.

Susceptibility of Varieties.—The degree of intensity with which the fungus attacks the fruit varies considerably. Difference in variety, soil, locality, and seasons are all determining factors. Whilst all varieties are probably more or less subject to scab, the following may be mentioned as being particularly liable to attack wherever grown:—

Apples—	*Pears*—
Bismarck.	Beurré Clairgeau.
Cox's Orange Pippin.	Beurré D'Amanlis.
Cox's Pomona.	Doyenné du Comice.
Duchess's Favourite.	Duchesse d'Angoulème.
Ecklinville.	Glou Morceau.
Keswick Codlin.	Pitmaston Duchess.
King of the Pippins.	Souvenir de Congress.
Lord Grosvenor.	Vicar of Winkfield.
Lord Suffield.	Williams Bon Chrétien.
Quarrenden.	
Warner's King.	
Wellington.	
Yellow Ingestre.	

The following varieties of *apples* are more or less resistant:—Beauty of Bath, Bramley's Seedling, Early Victoria, Grenadier, Lane's Prince Albert, and Lord Derby.

Measures of Control.—These consist of cutting out infected wood and spraying.

1. **Infected Wood.**—As it is largely from diseased shoots that the scab starts afresh each year, it is worth making a determined effort to attack the fungus in this position and also to prevent it from infecting the wood in future seasons. When the wood is badly diseased, as much as possible should be cut out without injuring the trees This should be com-

pleted by the end of March. This source of infection will in this way be reduced to a minimum, although a small amount is almost certain to remain. To prevent, as far as possible, the new wood being affected it is necessary to spray during spring and summer (*see* details below). If this is properly done it should be possible, not only to secure a clean crop that season, but to preserve to a large extent the new wood and thus eliminate this source of infection for the following season. It is particularly important to spray Cox's Orange Pippin and Lord Suffield (which develop scab badly on the wood), as the disease spreads from these to other varieties which would not otherwise be attacked.

2. **Spraying Mixtures.**—There are two mixtures which may be used for spring and summer control, namely Bordeaux Mixture and Lime-sulphur* (Burgundy Mixture has *not* been found suitable). Lime-sulphur is the more easy to prepare, but Bordeaux Mixture is undoubtedly the more effective, though in the case of a few varieties of apples it is apt to cause scorching. These varieties include: Beauty of Bath, Cox's Orange Pippin, Duchess's Favourite, Gladstone, James Grieve and Lady Sudely. On all of these a lime-sulphur spray only should be used. Bordeaux Mixture is safe to use on all varieties of pears and can be relied upon to prevent scab.

Application of Mixtures.—The dates at which the mixtures should be applied are of considerable importance. In very bad cases of *apple* scab two or even three applications are necessary, the first immediately before flowering, the second as soon as the petals fall, and the third about three weeks later. Where labour and time permit one spraying only, the third should be omitted in preference to the second. On *pears* the first spraying should be given directly the fruit is set and a second spraying three weeks or a month afterwards. It is particularly important with pears to spray the under surfaces of the leaves as far as possible.

The spraying should be carried out on a still day, and the mixture applied through a fine nozzle with a strong pressure and the leaves uniformly wetted with a very fine mist. Spraying should cease before the leaves begin to drip.

Preparation of Bordeaux Mixture.—The best formula for apple spraying in this country is: Copper sulphate, 4 lb., best quicklime (in lump form), 4 lb., and water, 50 gallons.

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* If caterpillars are likely to prove troublesome, lead arsenate paste may be added to either of these mixtures at the rate of 1 lb. to 20-25 gal. of the mixture. Further details as to the use of this substance, which it should be remembered is highly poisonous, will be found in Leaflet No. 4, *Winter Moths*, included in Sectional Volume No. 2, "*Insect Pests of Fruit Trees*," price 10d.

The copper sulphate* should be dissolved in a small *wooden* vessel at the rate of 1 gal. of water per 1 lb. of sulphate (iron or tin vessels must not be used). The lime† should be slaked to a fine paste with a little water in another vessel, and water added gradually to make a milk, and finally diluted in a large barrel to the requisite amount (46 gal.). The 4 gal. of copper sulphate may now be poured slowly into the diluted milk of lime and the mixture stirred thoroughly during the process. The two components of the mixture may be kept separately for a long time, but, after mixing, the spray fluid should be used as soon as possible—at all events within 24 hours.

Stock Solutions.—When used on a large scale it may be convenient to make up a stock of each ingredient which may be diluted down and mixed as required. For this purpose 50 lb. of copper sulphate may be dissolved in 50 gal. of water, and 50 lb. of lime, slaked and diluted to 50 gal. of milk of lime. Each gallon will then represent 1 lb. of copper sulphate and 1 lb. of lime. When required for use, the contents of the barrels should be thoroughly stirred and the requisite number of gallons taken out and diluted according to the above formula. For a 50-gallon barrel, for instance, 4 gal. of lime-milk should be removed and diluted with 42 gal. of water and when thoroughly stirred and strained the 4 gal. of copper solution may be added slowly.

Safety test for Bordeaux Mixture.—If the copper sulphate and quicklime have been weighed out accurately and properly mixed there is no need to test the Bordeaux Mixture before use. Should there be any doubt on this point, however, a simple and reliable test is the use of a bright blade of a knife which must not be greasy. The blade should be immersed in the liquid for at least a minute; if at the end of this time the blade remains unchanged in appearance the mixture may safely be used, but if it becomes stained more lime must be added.

" Excess Lime " Bordeaux.—On account of the scorching of the foliage and russeting of the fruit which is liable to occur on some varieties with the " equal lime " Bordeaux (4-4-50), an " excess lime " Bordeaux has been advocated in Canada and the United States. " Excess lime " Bordeaux is now being tested at the East Malling Research Station and preliminary trials with a mixture made at the rate of 4 lb. copper sulphate and 12½ lb. lime to 50 gallons of water

* Growers are strongly advised to buy their own copper sulphate and lime, and prepare their own mixture It is of great importance also that only pure copper sulphate be used and a guarantee of 98 per cent. purity should be obtained.

† It should be remembered that fresh quicklime is essential for making Bordeaux Mixture and that the air-slaked lime so often found in builders' yards is useless for the purpose.

gave promising results.* The damage in the case of James Grieve, Worcester and Allington, though not entirely eliminated, was much reduced and the high fungicidal effect was maintained.

Lime-sulphur.—This fungicide should always be used for delicate varieties such as those already noted and it may also be resorted to in cases where it is not convenient to prepare Bordeaux Mixture. It is not so efficient as Bordeaux but has the advantage over the latter in that the concentrated wash may be purchased ready-made in large or small drums so that it is only necessary to dilute it to the proper strength. Numerous brands of lime-sulphur of a guaranteed strength of 1·3 sp. gr. are on the market and these are to be preferred to those the strength of which is not guaranteed.

For spraying against scab " summer-strength " lime-sulphur, namely 1 gal. of concentrated solution mixed with 29 gal. of water, should be used. The lime-sulphur should be poured slowly into the water, stirred well, and used at once. *Spraying machines with copper parts should not be used for lime-sulphur spraying.* It should be noted that Cox's Orange Pippin and James Grieve are particularly sensitive, and for these varieties, and also for Wellington and Newton Wonder, half " summer-strength " is necessary, namely 1 gal. to 59 gal. of water.

As is the case in the United States and Canada, a reduction of crop occurs, especially with certain varieties, when lime-sulphur is used, a certain number of fruits falling in June. This matter is also being investigated at East Malling.

APPLE MILDEW.

(*Podosphaera leucotricha*, Salm.)

Apple Mildew is an extremely widespread disease and it occurs in almost all countries where the apple is cultivated. The mildew has been repeatedly studied, especially in Europe and America, and, with the exception of a few special cases, it is now possible to keep it under control if the proper measures be adopted. In England the disease is of common occurrence and may cause a considerable amount of damage, especially in the case of certain varieties. During recent years it appears to have been increasing in severity, and reports have been received from several apple growing centres in which, owing to serious and persistent outbreaks, extensive damage has been caused. Pears also are attacked by the same mildew, but in this country not severely.

* *See* N. H. Grubb. Tests of Fungicides on Apple Trees. *Journal of Pomology* (Vol. II, pp. 93-104). February, 1921.

FIG. 1.—APPLE MILDEW. Shoot, showing a "primary infection." The terminal bud was infected by mycelium in autumn, and with its opening in spring mildew developed on the leaves and flowers.

FIG. 2.—APPLE MILDEW. Mildewed apple shoot in August showing the whitened appearance of the "wood." The two whitened shoots should be cut away, as they are liable to give rise to mildew next year. The shoot to the left is, however, also mildewed and the bud probably infected. The cutting back, therefore, must take place lower down, as indicated by the black line.

Cause of the Disease.—Apple mildew is caused by the fungus *Podosphaera leucotricha*. It is closely related to the other powdery mildews, such as those of the Hop, Rose, and Gooseberry, and especially to that so commonly found on Hawthorn hedges. But it is distinct from all, and is confined in its attacks to members of the genus Pyrus. The fungus consists of the mycelium, very slender threads (corresponding to the spawn of a mushroom) which creep over the surface of the host plant, and masses of conidia or minute spores, which appear as a white mealy powder on the surface of the mildewed area, and which, like seeds, serve to propagate the fungus. The mycelium of the fungus obtains its nourishment by means of minute suckers inserted into the superficial tissues of the leaf.

Description of Affected Plants.—Affected leaves show the curled and white appearance characteristic of attack by most mildews. The mealy substance or mass of spores is at times very abundant and hence with favourable weather the disease spreads rapidly. The mildew commences each year with the unfolding of the buds in spring. Both flower buds and leaf buds may be affected (Fig. 1). In some cases the flowers are so injured that the whole truss fails to set and the buds die, and if many are thus attacked a considerable loss of crop may result. Leaf buds which are affected may in like manner be killed outright, but in the majority of cases they survive and continue to grow, each new leaf which develops being generally more or less affected with the mildew as also is the "wood" itself. The leaves or other part of the tree are infected by means of spores blown from the rosette of first formed diseased leaves or flowers, and from them additional spores are produced which provide for further infection.

The appearance of diseased trees later in the year varies with the season and the locality, but more especially with the variety of apple. In favourable seasons and in localities which do not suffer badly, the mildew, except for crippling a few shoots, does not cause extensive damage, and those varieties which in other districts are usually badly injured may escape almost entirely. In other localities, especially in parts of Cambridgeshire and Worcestershire, the mildew is always troublesome, and in the case of susceptible varieties (*see* list below) may so injure the leaves that by July a considerable amount of defoliation may take place. Such trees present a very characteristic appearance, the young shoots being devoid of leaves, except near the growing tips, and, if the attack has been very severe, altogether leafless (Fig. 2). The affected shoots are much weakened and most of them die back very considerably during the winter. If the number attacked in this way be not too great the mildew can, with judicious pruning, be controlled and the trees saved, but if such measures are not

resorted to whole trees will in course of time become so seriously injured as to be almost worthless.

Though the flower buds are often affected the fungus in later stages is confined as a rule to the shoots and leaves, but in a few varieties, notably in Lane's Prince Albert, it may attack and injure the young fruit. Bad cracking of the fruit of both apples and pears as a result of mildew attack has been reported from the Continent.

Method of Overwintering.—As is well known, the mildew fungi possess two kinds of spores, conidia or summer spores, and resting or winter spores. The former are produced very abundantly in spring and summer, their function being to distribute and reproduce the fungus during the growing season. The latter, which occur in minute spore cases termed perithecia, are formed later and normally remain dormant till spring, when they germinate and infect the new foliage. The apple mildew is remarkable in possessing an additional method of hibernation. Though its perithecia are now known to be produced more frequently than was formerly thought, they are, except on certain varieties, always scarce and often entirely absent. When they occur they are produced on the wood, usually at the base of the current year's growth. It is very doubtful, however, if the resting spores contained in these perithecia play any substantial part in the propagation of the disease, as it is quite certain that the first outbreaks of the mildew in spring are to be found, not scattered here and there on a few leaves as in cases resulting from spore-infection, but all over those of certain newly expanded buds. Careful examination makes it evident that the buds were infected before they had opened, and this implies that the mycelium of the mildew entered the young soft bud during the previous year and remained in the bud in a dormant state during the winter. This method of overwintering by means of hibernating mycelium is rare amongst mildews, but in addition to mildew of the apple it occurs also in that of hawthorn, coppiced oak and the garden Euonymus.

The infected buds as they open soon produce a crop of spores, consequently the leaves and flowers early assume the mildewed aspect and appear as white mealy rosettes (Fig. 1). These mildewed rosettes, which arise exclusively from the hibernating mycelium, are termed " primary " infections, and, as it is from them that all later infection directly or indirectly arises, it is clear that in seeking to eradicate the disease it is of the utmost importance that they should be removed.

The buds infected with hibernating mycelium are most often fruit buds, either terminal or spurs. But wood buds, especially terminals, are also invaded. The infected buds can hardly be distinguished from the normal, but all shoots

showing the whitened appearance of the wood (Fig. 2), recognisable even in winter, are liable to contain infected buds and should in consequence be pruned away. If this were done thoroughly the trees would be largely freed from mildew, as little secondary infection (unless introduced from neighbouring gardens or other trees) could arise.

When the leaves only have been attacked and the wood and buds have escaped infection, the mildew disappears with the normal shedding of the leaf in autumn.

Susceptibility of Varieties.—The varieties most susceptible to apple mildew are Lane's Prince Albert, Bismarck, and Cox's Orange Pippin. In the Wisbech and Evesham districts large plantations of the first two varieties may be seen completely ruined by mildew attacks. Amongst other varieties which frequently suffer are Bramley's Seedling, Grenadier, Irish Peach, Lord Grosvenor, Lord Suffield, and Mr. Gladstone. Very frequently young stocks 2 or 3 years old, both in this country and in America, are badly attacked by mildew, and in some cases killed outright.

Measures of Control.—1. *Winter Pruning.*—Since the new outbreaks commence each year from infected buds these latter should, as far as possible, be removed. When pruning the trees all shoots which were mildewed during the past summer, and recognisable in winter by the white appearance of the young wood should be cut away. The operation should be carried out early, as if delayed beyond the new year the distinction between the mildewed and the non-mildewed shoots may be lost.

2. *Cutting out in Spring.*—When the buds expand in the spring the trees should be gone over again, and all affected shoots, whether flower trusses or leaf-buds, should be carefully cut off and burned. If this operation and the previous one are carried out thoroughly, there will be little or no trouble with mildew unless the trees become infected from an outside source.

3. *Spraying.*—If as a result of the removal of all primary infections the trees are clean, but are known to be liable to serious infections from neighbouring gardens and other mildewed trees, it is advisable to spray with lime sulphur shortly after the blossoms set and again later if necessary (1 gallon lime sulphur to 30 gallons water, except for the delicate varieties, Cox's Orange Pippin, James Grieve, Newton Wonder and Wellington, for which 1 in 60 must be used).* This spraying, though of no value for keeping primary infection in check, will do much to prevent secondary infections, and will in this way help to reduce the number of bud infections which initiate the new outbreaks the following season.

* Lime-sulphur wash is now made by many firms, and is readily obtainable, but the manufacturers should be asked to guarantee that the concentrated wash is of 1·3 specific gravity.

BROWN ROT OF APPLES.

(*Monilia fructigena*, Pers.)

Brown Rot of Apples carries off hundreds of tons of ripe or half ripe fruit every season. The soft brown patches of decay commence as mere spots and gradually increase in size until the whole apple is affected, while, small pustular swellings appear beneath the skin and soon burst through as yellowish, powdery, cushion-like outgrowths, usually in concentric circles (*see* Fig. 1 *b* and *c*). The diseased apples ultimately shrink in size and the skin becomes wrinkled. Such fruits, when hanging loosely, are easily detached, and many fall to the ground during a high wind; the rot continues to develop on these windfalls, and more pustules are produced, which act as sources of further infection. When, however, a diseased apple is in contact with other apples, or with a branch, the pustules produced at the point of contact become adherent and may so attach the apple to the tree that some little force is required to detach it.

Method of Attack by the Parasite.—The disease is caused by the fungus *Monilia fructigena*, Pers. The powdery pustules which appear on the affected apples are the reproductive bodies of the fungus growing in the flesh of the fruit, and each consists of numerous chains of spores or reproductive bodies. The spores fall apart readily and are scattered by the wind or carried by insects to other apples. If they gain access to the flesh of an apple through a cut or rupture of the skin they germinate, producing fungal threads (*mycelium*) which develop within the tissues of the apple and cause the characteristic "brown rot." The rot extends very rapidly and within a week or ten days the fruit will be destroyed.

When a diseased apple is in contact with others on the tree, the latter may become infected by contagion; frequently a bunch of apples is found which shows fruit with the rot in various stages of development. Fig. 1 is a photograph of such a cluster of apples obtained in late summer from a tree of Warner's King. The disease had commenced in the small withered apple (*a*); below this and in contact with it is another apple (*b*) which had evidently been affected for some time as it is much shrunken and wrinkled. The rot had extended from this apple to the one on the left (*c*), which, at the time the photograph was taken, was permeated with the fungus and bore numerous powdery pustules; but it was only very slightly shrunken and its surface showed but little wrinkling. On the right is an apple which is still quite sound.

Mummied Apples and Methods of Overwintering.—Those diseased apples which become attached to the tree usually

FIG. 1.—BROWN ROT OF APPLES. A cluster of apples affected by Brown Rot showing the spread of the disease from fruit to fruit. (For description—*see* text.)

FIG. 2.—BROWN ROT OF APPLES. Two mummied apples as found on the trees in winter. The mummies should be removed as they are permeated with the fungus which will develop spores and thus bring about the infection of the new apples in summer.

FIG. 3.—BROWN ROT OF APPLES. Fruiting spur, from a tree of Lord Derby, bearing pustules of the same fungus.

remain in that position throughout the winter, becoming dry and shrivelled, and they constitute the so-called " mummied " fruits (Fig. 2). Many of the spores on the pustules of these " mummies " are washed away by rain in winter or dispersed by the wind; others remain on the pustules but usually lose their power of germination. As summer approaches, however, the " mummies " produce a new crop of spores and cause infection of the young fruit. A " mummy " frequently infects the growing apples through direct contact, but in any case apples in the neighbourhood of a " mummy " are liable to spore-infection and such newly-infected fruit will soon produce myriads of spores which serve to spread the disease. The spores are very minute in size and are easily dispersed by wind. Insects, too, crawling over the fruit, may not only carry the spores from one apple to another, but, in the case of biting insects, such as wasps, produce wounds which enable the spores to reach the exposed flesh of the apple, where they develop mycelium and reproduce the rot.

Spur Canker.—On some soft-wooded varieties of apples (*e.g.*, Lord Derby and James Grieve) the disease may extend along the stalk of the affected fruit into the fruiting spur, or even as far as the branch itself, producing in the latter a canker round the base of the spur. In this capacity of forming cankers the fungus resembles the " Blossom-Wilt " fungus (*see* Leaflet No. 312). The two diseases are, however, quite distinct. In the case of " Blossom-Wilt " infection occurs through the open flower while, in the disease here described, infection takes place, so far as is known, only through the fruit. Fig 3 shows the pustules of the Brown Rot fungus occurring on a fruiting spur.

The Disease on Stored Apples.—The Brown Rot fungus attacks apples not only while still growing on the tree, but also after they are picked and stored. The fungus spreads readily by means of spores and by direct contact in the store room; it may cause serious losses. Through careless selection and packing extensive decay may also occur in apples boxed for sending to a distance.

Under certain conditions stored apples affected by *Monilia fructigena* turn black, the skin remaining smooth or nearly so for some time and bearing few or no pustules. Although there is often no evidence on the exterior of such apples that a fungus is present, the flesh is permeated by fungal threads, and particles of the flesh, placed on suitable culture media, give rise to the growth and pustules typical of *Monilia fructigena*.

Measures of Control.—1. *Removal of Mummies in Winter.*—The best preventive measure is the removal and destruction

of all mummies during winter. The mummies should be collected and either burned or deeply buried.

2. *Removal of Affected Fruit in Summer.*—In gardens and small orchards it is possible to go over the trees at intervals during the season and remove all fruit showing the slightest signs of Brown Rot. In large orchards such a course is not always practicable, but every effort should be made to remove diseased fruit as early as possible. It might be removed at the time of picking, the diseased apples being gathered and either destroyed at once or dropped on the ground, where they are less dangerous than if left hanging on the tree.

3. *Cutting out of Cankers and Infected Spurs.*—All infected spurs, together with cankers on the stem, should be cut out. This operation is best performed in summer when the dead or dying spurs are conspicuous, but it may be carried out in winter provided it is completed before the fungus resumes its growth in spring.

4. *Picking and Handling.*—Brown Rot will set in wherever there is a wound. The greatest care therefore should be taken not to injure or bruise the fruit, especially during the picking and packing.

5. *Precautions as to Storage.*—When storing, all fruit showing signs of Brown Rot should be discarded, for the disease will not only continue to develop in the affected individuals, but will spread to others. These precautions should be regarded even more scrupulously when apples are boxed for transmission to a distance.

BLOSSOM-WILT OF APPLES.

(*Monilia cinera*, forma *mali*.)

Blossom-Wilt is a comparatively new disease. It is a trouble which affects not only the blossoms but the spurs and the shoots. The disease was first described from Kent, where it is very common, but it is now known to occur in many other parts of the country and to be responsible for serious losses of crop. In some orchards it has reached epidemic proportions and in many cases the apple crop may be reduced to one quarter or even less. Lord Derby is the variety most often attacked, but Cox's Orange Pippin, James Grieve and many others also suffer.

The disease is caused by the fungus *Monilia cinerea*, a very near ally of *Monilia fructigena*, the cause of Brown Rot of apple fruit (*see* Leaflet No. 86). The two fungi may be distinguished by the colour of the spore-pustules, those of the former being a pale grey and of the latter being buff. Other and sharper distinctions are discernible by laboratory methods. *M. cinerea* is best known on plums and other stone fruit, and the form which attacks apple blossom is known as forma *mali*.

FIG. 1.—"*Blossom-Wilt*" *Stage.* Branch bearing several infected trusses.

BLOSSOM-WILT OF APPLES.

FIG. 2.—A dead spur and canker which has half girdled a branch. Winter condition showing spore-pustules present on the spur.

FIG. 3.—Portion of a large canker from a young tree of Lord Derby apple showing numerous spore pustules.

The "Blossom-Wilt" Stage.—The first evident symptom of the disease, which, in its early stages, is easily overlooked, is the "blossom-wilt" condition (*see* Fig. 1). About a fortnight after the flowers begin to open, the leaves on some of the spurs will be seen to be beginning to wilt; within a day or two these drooping leaves become brown and withered, usually with incurved margins. The flowers of such trusses will be found to have wilted and to be brown and dead. In susceptible varieties many trusses on a tree may be affected. The destruction of the blossoms is, however, only a minor part of the damage caused by the fungus, as, after killing the flowers, it usually proceeds to grow through the flower stalk into the spur.

The life-history of the parasite has been worked out by Dr. H. Wormald, of Wye College.* He showed that the infection of the flower-truss takes place through spores alighting on the stigmas of the blossoms. These spores are derived from the spore-pustules which develop on the spurs and wood which was attacked the previous season. It was ascertained that the death of the flower follows very soon after the infection of the stigma, and within a fortnight the fungus has so far advanced as to affect the young leaves and cause them to droop as noted above. If the weather is dry the fungus keeps within the tissues of the flowers and leaves and does not show itself at all from without, but in moist weather it develops externally on the flowers and flower-stalks in the form of small, rounded, grey pustules similar to those found on the spurs.

The Attack on the Wood.—On the wood the fungus may (1) attack and kill the spurs, (2) grow along the spur into the shoot and form a spur canker, and (3) occasionally extend considerably in the branch and kill extensive areas. An example of an affected spur with a canker at its base is seen in Fig. 2, whilst Fig. 3 shows the killing of large areas of the branch. The amount of canker which develops on the shoot varies. In some cases the shoot may be only half girdled (*see* Fig. 2), but in other instances the girdling may be complete, in which case the portion of the branch above the canker dies. The mycelium in the canker does not appear to spread after the end of June, as the cankers do not increase in size after that date.

In Figs. 2 and 3 the grey spore-pustules of the fungus are seen on the surface of the bark, having been pushed out by the mycelium from within. Though the pustules develop on the flowers soon after infection, they do not make their appearance on the newly-killed spurs and shoots until the winter. About December immature pustules may be found

* For a fuller description see article by H. Wormald in *Jour. Board Agric.*, Vol. XXIV., Aug. 1917, pp. 504-513.

bursting through the bark, which continue to increase in number during the winter months. In spring they become powdery in appearance, owing to the ripening of the spores, and by the time the trees are in bloom they are liberating spores in myriads. These are blown on to the opening flowers and produce Blossom-Wilt.

Method of Spread.—As already explained, the disease is spread by the spores of the fungus being blown on the open flowers. It was found at Wye that the wilted trusses are far more numerous in the vicinity of cankers and dead spurs bearing spore-pustules, those trusses situated immediately below such spurs or cankers being particularly liable to become attacked with Blossom-Wilt. Thus, though infection through spores carried by the wind from one tree to another or from one plantation to another does to a certain extent take place, the great majority of new attacks on any given tree arise from spores produced by pustules on the same tree. *The great importance, therefore, of removing all wood which bears pustules is obvious.*

Damp weather favours spore-production; and such weather also retards the " setting " of the flowers and so keeps them in a condition in which they are liable to become infected by spores for a longer period.

Varietal Susceptibility and Damage Caused. — The varieties Lord Derby, Cox's Orange Pippin and James Grieve are extremely susceptible, but, in addition, the disease occurs on the following:—Ecklinville Seedling, Duchess of Oldenburg, Worcester Pearmain, Allington Pippin, Early Julyan, Lane's Prince Albert, Lord Grosvenor, Prince Bismarck, Chelmsford Wonder, Newton Wonder, Domino, Beauty of Bath, Warner's King, Keswick Codlin, Bramley's Seedling, Duchess' Favourite, Rival, Fearn's Pippin, Dartmouth Crab, Ribstone Pippin, and Hanwell Souring.

In the highly-susceptible varieties, the Blossom-Wilt stage is very conspicuous, and it is not uncommon to find 50-75 per cent. of the flower spurs killed by the disease in a single season. In Lord Derby the wood is very extensively attacked and stretches of wood 1-2 feet in length may be found completely killed, the mycelium spreading from the spur-canker along the shoot and forming hundreds of spore-pustules (*see* Fig. 3).

Of varieties resistant to Blossom-Wilt, Bramley's Seedling is the only one which shows this character to a very marked degree.

Measures of Control.—1. *Spraying.*—So far little success has been obtained on a field scale by spraying. Owing to the delicate nature of the floral organs, a strong spray cannot be applied to protect the stigmas from the spores which produce

Blossom-Wilt, and owing to the difficulty of wetting them, it is almost impossible to kill the pustules on the wood.

The most promising results have been obtained by a winter wash containing caustic soda and soft soap, which if properly applied will sterilize the pustules for two or three weeks. The wash should contain 1 per cent. caustic soda and 1 per cent. soft soap, that is, 1 lb. caustic soda and 1 lb. soft soap in 10 gallons of water. A slightly stronger solution would be preferable, but, unless the mixture can be kept warm, it becomes glairy or curded. The wash should be applied immediately previous to the swelling of the buds.

2. *Cutting Out.*—The most successful line of treatment at present is the cutting out and burning of all infected spurs and cankers.

The periods at which this can be done should be carefully noted. Wherever possible, cutting out should be carried out during the summer when the brown withered leaves of infected spurs contrast with the living ones and constitute a sure guide to places where the knife is required. If, through lack of labour, pruning is left over until winter, the affected parts are not so readily seen and the cutting away is therefore more difficult. Cutting out can take place any time in winter, but it is essential that it should be finished before the buds open. During the winter, however, even with the greatest care, a few diseased spurs are liable to be overlooked. Trees should therefore be gone over a second time.

Another point to note when removing the dead spurs and cankers is that it is necessary to cut back to the sound living wood. It is not sufficient to break off the withered trusses since some of the mycelium is invariably left behind and this continues to develop and to produce pustules.

CROWN GALL.

(*Bacterium tumefaciens.*)

The swellings or galls termed Crown Gall occur on a great variety of herbaceous and woody plants. They are abundant on various kinds of nursery stocks, particularly apple stocks, but, amongst fruit, pear, quince, plum, cherry, apricot, peach, raspberry, loganberry and blackberry also suffer, and in America bad cases have been noted on gooseberries. Plants of many other kinds are attacked, chrysanthemum, hollyhock, beet, mangel, and amongst stocks other than fruit trees, Manetti roses are particularly susceptible. The disease is now found in most parts of the British Isles, nurseries having distributed affected stocks not only all over England, but to many other parts of the world. Although not so serious in its effects as are most diseases the health of plants attacked by Crown Gall usually suffers sooner or later, the effects

being seen in dwarfing of growth or direct injury to roots or branches, some plants being more seriously affected in this way than others. Apart from actual injury, the disease causes the plants to appear unsightly and renders the stock unsaleable. For this reason it is important to take what steps are possible to control the disease.

It should be noted that *galled plants will not be certified for export*, hence special attention to preventing attacks should be given by all growers of fruit trees, roses and other plants for export to America or other countries.

Cause of the Disease.—Crown Gall has been known for very many years and has been the subject of much speculation and investigation, but only comparatively lately has its true nature been discovered. The disease in all its forms and on a large number of plants has been the subject of the most intensive study for over fifteen years by Dr. Erwin F. Smith and his colleagues in the Department of Agriculture at Washington. They have proved beyond question that the disease is infectious and is caused by a bacterium which they have named *Bacterium tumefaciens*. The galls can be produced at will by inoculating appropriate tissues of healthy plants with cultures of the bacterium. The bacteria are excessively difficult to see in the tissues of the galls and, hence, for long escaped recognition. The American work has, however, quite recently been confirmed in England in the case of the Paris Daisy (*Chrysanthemum frutescens*); the same bacterium has been isolated and inoculations with the organism have produced new Crown Galls.* Further work on the Crown Gall is being pursued in this country at more than one research institute. On the practical side the disease is being investigated at the East Malling Research Station, and the Ministry is indebted to Mr. N. H. Grubb of that station for the notes given below on English fruit stocks.

Description of the Disease.—In its typical form Crown Gall manifests itself as roughly spherical swellings which may vary in size from that of a pea to that of a cricket ball. The galls are at first white and soft, but gradually become hard and dark in colour. On nursery stock they often decay and fall away at the end of the season. Hedgecock has distinguished the more woody perennial form usually found on older trees as "hard crown-gall." These are slower growing, but continue to enlarge for many years and become very hard. On old plum trees very large galls, 8 or even 10 inches in diameter, may sometimes be found.

The position of the swelling also varies considerably. As the name implies the galls are often found at the crown or collar of the attacked plants, but they may occur on the roots

* *Ann. Bot.*, Vol. XXXV, pp. 137-8.

(*Photo:* *Dr. H. Wormald.*)

FIG. 1.—CROWN GALL as the base of the stem on young seedling apple stock.

Fig. 2.—Crown Gall on young Rose cutting. Rather a large specimen.

Fig. 3.—Hairy Root form of Crown Gall on an American variety of Apple.

(Photos: Presented by Prof H. H. Whetzel, Cornell University, U.S.A.)

or on the stems and branches. The latter is the usual form in raspberries. Where root-grafting is practised they are particularly frequent at the junction of the stock and scion.

In the case of apples it is found at East Malling that in stocks raised from layers or stools, by far the largest proportions of galls occur on the base of the stem at the point where it was separated from the parent stool or layer. Infections higher up the stem are sometimes found and others on lateral roots, but galls at the ground level, or " crown " of the stock are rare. The galls on these stocks usually take the form of rough warty swellings of soft tissue which vary in development from a slight irregularity of the " callus " to large, more or less spherical galls up to three or four inches in diameter.

A form very different in appearance is frequent in America and is known as " Hairy Root " (*see* Fig. 3). In this case dense tufts of fibrous roots are produced on various parts of the root system. These have been found to be caused by the same bacterium as that causing Crown Gall, the bacteria being found in the flattened tumours on the main root from which the tuft of fibres arises. Various types of Hairy Root have been recognised, but in this country, though suspicious cases have been observed, no instances have been seen which can with certainty be referred to that disease.

Method of Attack.—It has been proved by direct inoculation and other experiments that the bacteria gain entrance through wounds and in all probability they cannot enter an uninjured surface. This has been confirmed by trials in nurseries where plants intentionally wounded gave rise to four times as many galls as those not so treated. It is well known also that seedlings are less often attacked. In the case of cuttings and root grafts the period during which the plants are vulnerable is just prior to and during the formation of the callus.

Once inside the tissues the bacteria multiply, but instead of destroying the cells they stimulate them to divide and enlarge, much in the same way as the Wart Disease fungus does in the case of the potato tuber, and a gall or tumour is produced. Crown Gall is, however, peculiar amongst plant parasites, in that, in certain plants at any rate, the affected areas form strands (termed tumour-strands) in the healthy tissue along which the bacteria travel, and from which other galls arise, sometimes at a considerable distance from the original gall. This fact explains why it is that new galls arise in other spots if the primary gall is removed.

Extent of Injury.—The amount of damage caused by Crown Gall varies greatly in different crops. In some cases it is almost negligible. Stone-fruits suffer more than apple or pears. Soft fruits such as raspberries have been so injured in

Sweden as to bear practically no crop and similar cases have been recorded in England. On the vine Crown Gall is regarded as a serious disease in France and Italy. Manetti roses, which are singularly subject to attack (*see* Fig 2), are said to be much impaired for the uses for which they are required in America.

Few precise data have yet been collected in this country on the nature and extent of the injury which is caused. In apples, recent work tends to show that its effects are comparatively slight and not so serious as was at one time thought. The amount of injury varies in different varieties, not only as regards the stock, but with the variety of apple grafted on it. In America affected trees are liable to be retarded in development and dwarfed in growth. Early death sometimes takes place. The root system is often interfered with, as a result of which the trees suffer. On the other hand, in some cases the stocks appear to be able to throw off the disease entirely. In England it has been observed that during the first few years after planting galled trees often grow almost, if not quite, as well as trees free from galls. The amount of injury which takes place depends largely on the position of the gall on the tree, galls at the crown, for instance, being more serious than those on lateral roots. Those galls, moreover, which have a narrow neck are less harmful than those which are attached by a broad base.

In addition to direct damage Crown Gall may be dangerous in that it affords a means of entry for various parasitic fungi. Further, the distribution of diseased stock among new and clean orchards may lead to serious injury to other plants such as raspberries and loganberries, which may subsequently be planted. It is quite plain, therefore, that the disease cannot be disregarded. Galled plants cannot be exported and will not be accepted readily by buyers at home.

With regard to the susceptibility of apple stocks it has been noted at East Malling that the different sorts of Paradise differ markedly. The most susceptible are certain types which root rather poorly when layered and which consequently have to be torn or broken from the stool, instead of being cut with the knife, *e.g.*, the Doucin. While evidently this is due partly to the ragged wound made by tearing the stock from the stool, there is, apart from this, evidence of variation in susceptibility. No kind of apple stock has yet been found to be immune, and traces of the disease have been seen on several kinds of " Free " stocks, which have been propagated by layers, as well as on all the common forms of " Paradise."

Distribution in Britain.—The Crown Gall bacterium is widely distributed in gardens and orchards and especially in the soils of nurseries. This is evident from records kept by the Ministry of Agriculture and receives confirmation from

the frequent occurrence of galls on stocks, canes and trees received from all parts of Western Europe at the East Malling Research Station over a period of nine years. Judging by the large percentage of attacked plants it would appear that the disease must be exceedingly prevalent in certain localities. From Erwin F. Smith's work it is clear that the bacteria causing the galls show little specialisation into distinct races according to their hosts, but can, if opportunity offers, attack a large range of plants. The importance, therefore, of preventing the distribution of diseased stock and the infection of clean areas is obvious.

Measures of Control.—1. *Clean Soil.*—In the case of Manetti roses which are particularly liable to infection it is highly desirable when propagating these plants to avoid soil badly infested with the Crown Gall bacterium. If possible new or entirely clean land should be selected.

2. *Prevention of Wounds.*—It has been shown that the bacteria invade the plant through wounds, and that in all probability they cannot enter an uninjured surface. The greatest care, therefore, should be exercised in not injuring the stocks more than necessary. This applies not only to their propagation, but to subsequent cultivation; all unnecessary shifting, heeling-in, &c., should be avoided.

3. *Budding and Grafting.*—Where Crown Gall is liable to occur, special care should be exercised in the operations of grafting and budding, since very frequently the junction or point of union is subsequently planted below ground, thus offering a wound for immediate infection. Scions should be placed on stocks of appropriate size and the graft protected by careful wrapping.

4. *Treatment of Attacked Stocks and Trees.*—It should be clearly understood that the removal of a gall from a plant does not necessarily free the plant from the disease. As explained above, the bacteria, in certain plants in any case, spread in the tissues by means of the tumour strands and, if the gall is merely cut off, the disease may break out again later. On the other hand, if a deeper wound is made with the object of cutting out the whole infected area, the wound may be more serious than the gall itself and may injure or even kill the tree. If the galls are on the lateral roots and only a few are attacked the affected roots should be cut out, but if badly galled the trees should be burned.

SILVER LEAF DISEASE IN FRUIT TREES.

During recent years fruit growers have suffered very severe losses from the disease known as Silver Leaf. The trouble is particularly common on trees belonging to the Family *Rosaceae*, for example, plum, apple, almond, apricot, cherry, peach,

nectarine, and Portugal laurel, but trees and shrubs belonging to altogether different families are also affected. Amongst these may be mentioned currant, gooseberry, horse chestnut, laburnum, and tree lupin. It is, however, to the plum, and to a less extent the apple, that Silver Leaf has caused most serious loss, the Victoria variety especially having been attacked and killed in large numbers, so much so that unless drastic measures are taken to prevent the spread of the disease this valuable variety of plum is threatened with extermination. It is also a frequent source of death to laburnums and flowering almonds in suburban gardens.

Description.—As the name implies, the foliage of trees suffering from Silver Leaf disease develops a silvery or leaden sheen which usually commences in a single branch. After a time the affected branch usually begins to die back, and as branch after branch becomes attacked large portions of the tree die, with the result that in time the whole tree is killed. The length of time between the first silvering and the death of the tree varies with the species or variety, the extent of the attack, and other factors. If affected branches are removed as soon as the first signs of attack are manifest, trees may often be saved, and occasionally affected trees recover without any treatment whatever. As a general rule, however, unless promptly attended to, the tree ultimately succumbs. After the death of a branch, but not necessarily after the whole tree has died, a purple fungus named *Stereum purpureum* will usually be found pushing its way through the dead bark and forming flat incrustations (*see* Fig. 2) or bracket-shaped bodies (*see* Fig. 3) on the surface of the branch. These structures are the reproductive portions of the fungus, and produce innumerable spores. The fungus itself had been present in the wood of the tree for one or more seasons and had been responsible, as explained below, for the silvering of the foliage and the death of the branches, but it was only after the latter had died that it proceeded to develop externally and to produce its fructifications.

Cause of the Disease.—Although further research is needed as to the nature of Silver Leaf, and many problems connected with it await elucidation, authorities are agreed that *Stereum purpureum* is capable of producing Silver Leaf, and that this fungus is primarily responsible for the disease in fruit orchards all over the country.

The scientific knowledge which is possessed as to Silver Leaf is due exclusively to the work of British botanists, and for the last ten years Mr. F. T. Brooks of Cambridge has made the disease a special study. This writer pointed out that the wood of a plum branch possessing silvered foliage practically always shows dark brown or blackish markings when cut across (*see* Fig. 4), although in the early stages of

FIG. 1.—Upper part of silvered Victoria Plum tree, one branch of which is dead and bears fructifications of *Stereum purpureum*.

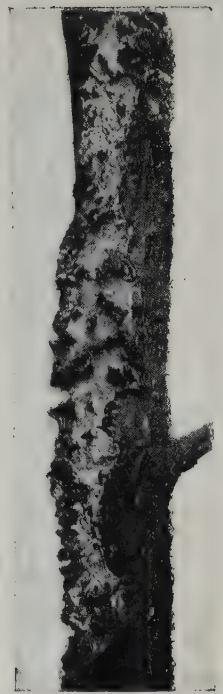

FIG. 2.—Fructifications of *Stereum purpureum*, flat form, on dead branch of Victoria Plum tree.

FIG. 3.—Fructifications of *Stereum purpureum*, bracket-shaped form.

(*Reproduced from* Journal of Agricultural Science, *Vol. V, Part* 3, *by kind permission of Mr. F. T. Brooks and Camb. Univ. Press.*)

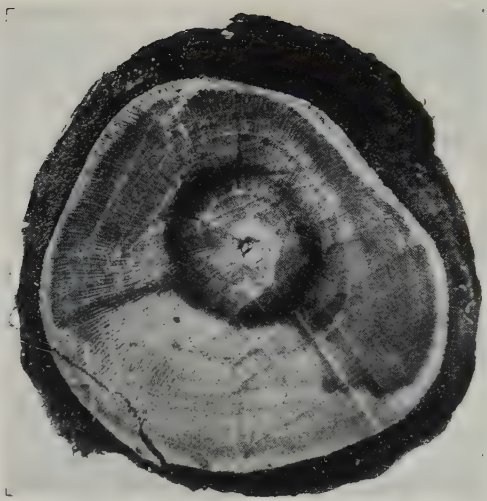

Fig. 4.—Cross section of branch showing diseased wood, dark in colour, and sound wood. Twice natural size.

Fig. 5.—Blenheim Orange Apple tree that has died after being regrafted. The scions also have died and the stock bears fructifications of *Stereum purpureum*.

(*Reproduced from* Journal of Agricultural Science, *Vol. V, Part 3, by kind permission of Mr. F. T. Brooks and the Camb. Univ. Press.*)

attack this discoloration is usually considerably below the silvered leaves. Microscopic examination revealed the fact that the discoloured portion of the wood contained the fine threads of fungus mycelium and that the brown colour was due to the presence of gum. Brooks further showed that if portions of the mycelium of *Stereum purpureum* (derived either from naturally-grown specimens or from the fungus grown in pure culture) were inoculated into a healthy plum tree under conditions which precluded the possibility of infection from other sources, precisely similar mycelium was produced, together with the discoloration of the wood and the formation of gum. The foliage also developed the characteristic silvery appearance. This experiment has been performed over and over again on various kinds of plum and at different seasons of the year with the same result. Inoculations with the spores of the fungus also produced the same effect. No silvering of the foliage, however, occurred if cuts were made but no *Stereum purpureum* inserted, or if some other fungus (such as *Stereum hirsulum*) was employed instead. It is important to note that if the silvered foliage is examined no mycelium is found in the tissues, nor as a rule is there any found in the upper part of the affected branch and twigs, at all events in the early stages of attack. The fungus is confined to the discoloured portion of the wood which occurs lower down, sometimes in the trunk though its effects are seen in the silvering of the foliage. The silvering itself is found to be primarily due to the accumulation of air below the epidermal cells, much in the same way that, owing to the presence of air, a white streak often shows in a block of ice when it is cracked. The epidermal cells have a tendency to break away from the cells immediately below, and the presence of air interferes with the normal reflection of light from the surface of the leaf.

From correspondence in the horticultural press it is evident that many persons have not appreciated the above facts and are still concerned with theories and speculations as to the cause of Silver Leaf, or occupied with side-issues. There is occasionally a silvering of plants, due to an unknown cause, which simulates Silver Leaf caused by *Stereum purpureum*, and the loss of colour in leaves suffering from a bad attack of red spider or aphis may also sometimes be confused with the true disease. *It should be clearly understood, however, that Stereum purpureum is the responsible parasite in the fruit plantations of the country*, and that all other theories which have been put forward to account for Silver Leaf in association with the dying of fruit trees are erroneous.

Description of the Fungus.—It is important that growers should learn to recognise the fungus causing the disease, as it may occur on the dead wood of other trees besides plum, and should not be allowed to persist in gardens. By the Silver

Leaf Order, moreover, all wood harbouring it must be burned. (*See* last paragraph of this leaflet.)

The fructifications of *Stereum purpureum* are purple-mauve when fresh, often with a white or pale woolly margin, but they become dingy in colour with age. In consistency they are leathery. They are very variable in form and appear either as flat incrustations up to several inches long covering the under surface of the branches or on the sides of the trunk (*see* Fig. 2), or as bracket-shaped projections of ¼-in. to 1-in. in width, and arranged in tiers one above the other (*see* Fig. 3). In this case the upper surface is hairy, and the under surface smooth. The purple colour, however, is the characteristic feature of young fructifications, and no other fungus of this colour occurs on plum.

The spores are produced in abundance on the smooth under surface of the fructifications. Although the latter shrivel up in dry weather they are capable of reviving with rain and discharging a fresh crop of spores. In this way the spore-discharge from a given fruit body may last over a long period. The fructifications appear at any time of year when the weather is moist and mild, but they are produced in the greatest abundance after the heavy rains of autumn.

Method of Spreading.—The fungus is propagated by the spores which are freely distributed by wind. They germinate readily in moist weather, and the fungus gains admission to the trees through wounded surfaces such as pruning wounds, cracked branches, injured trunks, fissures in the bark, and any other unprotected wounds. On germination, mycelium is produced which first of all attacks the exposed tissues, but subsequently invades the woody tissues below the wound. It has been shown that infection by spores cannot take place through the sound and uninjured bark.

Where the roots of two trees overlap, the mycelium from a diseased root may attack a sound root if in actual contact with it, and thus spread the disease, but this is of rare occurrence. The mycelium, however, does not spread through the soil itself, but in or along portions of the woody roots. According to Brooks, however, it is not by means of the roots that the disease is generally spread, and in support of this it will be noted that affected trees, for instance in a plantation of Victorias, usually appear scattered about in an irregular manner, and do not radiate from definite centres.

Silver Leaf is especially prevalent in trees which have been cut down and regrafted, and in the case of apples it is often only top-grafted trees which suffer to any large extent. The varieties badly attacked when top-grafted or otherwise severely cut, are Newton Wonder, Early Victoria (Emneth Early), Lord Suffield, Lord Grosvenor, Manx Codlin,

Ecklinville and Pott's Seedling. The explanation, doubtless, is that the unprotected exposure offers exceptional facilities for spore-infection. If infection occurs and mycelium develops in the stock it usually spreads to the graft and brings about its rapid death. Fig. 5 shows a tree where the fungus obtained an entry soon after grafting and where the scions made little growth.

In connection with spore-infection it should be remembered that the spores which give rise to new infections do not necessarily originate from a tree of the same kind. *Stereum purpureum*, for instance, is often found on laburnum and poplars in gardens, and Brooks has shown that spores from these host-plants may bring about Silver Leaf in plums.

Susceptibility of Plum Varieties.—All varieties of plum are liable to Silver Leaf. At one end of the list stands Victoria, by far the most susceptible of all, with Czar (very subject to the disease in certain localities) as second, and at the other end River's Early Prolific and the Yellow Pershore, which are highly resistant. The explanation of the frequency of attack in Victoria has been sought in its heavy cropping powers which not only weaken the trees, but bring about breaking of the branches, thus affording points of entry for the fungus. This is, however, probably only partly responsible, the true explanation doubtless lying in those subtle factors which govern susceptibility and immunity in all kinds of plants and animals.

Measures of Control.—Although no cure for Silver Leaf is at present known, the following recommendations, if carried out thoroughly, will materially help in checking the spread of the disease:—

1. *Removal of Trees and Cutting out Branches.*—Some growers advocate the removal and destruction of all trees showing silvered foliage; but, judging from experience in Cambridgeshire on a fairly extensive scale, it appears that this drastic treatment is not necessary. If affected trees are systematically and energetically dealt with as soon as the disease appears, it is possible very considerably to control its spread. To effect this the following operations must be rigorously enforced:—

(*a*) All dead trees must be grubbed up and destroyed, and all branches which have begun to die back must be cut out.

(*b*) Silvered plum branches if observed in an *early* stage of attack may often be cut out with advantage and the disease thereby prevented from extending to the other parts of the tree. If, however, the tree is more or less generally silvered the trunk is probably affected by the fungus, and the only sound policy is to wait until the tree begins to die back or alternatively to recover. It is not usually worth while to cut out silvered apple

branches as the chances of natural recovery are greater than in plums. If branches are excised they should be cut back flush with a larger branch or the main stem.

2. *Protection and Prevention of Wounds.*—This is exceedingly important. **All wounds made by the removal of branches should be pared over with a knife, and covered at once with gas tar.** As tar often loses its effect after about three months it is necessary, in the case of the larger branches at any rate, *to renew the tar dressing at frequent intervals.* Wounded surfaces made by the breaking off of branches through wind or other causes should be pared and tarred in the same way, and in the case of the highly susceptible Victoria, branches which have cracked through heavy crops of fruit should be cut off.

Wounds made in nursery work should be protected by a suitable grafting wax where there is danger of tar injuring delicate tissues. Fruit trees should be shaped properly when young so that apart from any necessary pruning of slender shoots, there should be little or no need to cut out branches at a later stage.

3. *General Measures.*—Accumulations of woody débris must not be allowed. Sawn-off branches and trees that have been grubbed up should be removed from the plantation immediately and be used for firewood. Small branches should be burnt on the spot. To cut down dead trees without subsequently removing them is useless, and to keep a wood-pile in or near a fruit garden is a practice that cannot be too strongly condemned. Tree stumps, *e.g.*, poplar, occurring on the borders of fruit plantations should either be removed or covered with soil, as they are liable to give rise to fructifications of *Stereum purpureum.* (*See* Silver Leaf Order below.)

Drainage also should be attended to. Silver Leaf is believed to make more rapid headway on heavy soils and in damp situations. Any improvement, therefore, in the drainage of an orchard will help the trees to resist the disease.

The application of lime, moreover, must not be neglected. Where the soil is sour through lack of lime, the general health of the trees suffers, and, as a consequence, they more readily fall a prey to disease.

Finally, good cultivation will tend to increase the chances of natural recovery.

4. *Resistant Varieties of Plums.*—Where Silver Leaf has been very severe it is advisable to plant plums other than Victoria or Czar. This applies especially to cases where the ground is surrounded by orchards or plantations in which the disease is still rampant and where the new trees will be in constant danger of spore-infection. Of varieties to be recommended, Pond's Seedling, Monarch, Purple Egg Plum and Damsons are generally fairly resistant, whilst Pershore

Yellow Plum, River's Early Prolific, Blaisdon Red and Damascene are seldom attacked.

Silver Leaf Order of 1923.—This Order, made under the Destructive Insects and Pests Acts, 1877 and 1907, requires occupiers of any premises on which plum and apple trees are growing to cut off and destroy by fire on the premises all the dead wood on each plum and apple tree before the 15th of July of every year. Where the dead wood on the trunk extends to the ground the whole tree, including the root, must be burned. An occupier may also be required to destroy wood of any kind of tree whatsoever on which Silver Leaf fungus is visible. Any Inspector of the Ministry of Agriculture may enter premises on which he has reason to suspect the presence of trees or bushes to which this Order applies.

WITHER-TIP AND BROWN ROT OF PLUMS AND CHERRIES.

(*Monilia cinerea*, forma *pruni*.)

The decay of ripe plums known as Brown Rot is a disease familiar to all growers. It is a serious trouble wherever plums are cultivated, and the losses occasioned, both on the trees and in market consignments, are often very heavy. Quite as serious, and at times more serious, is the attack by the Brown Rot fungus on the flowers and shoots. This form of attack, which is known as "Blossom-Wilt and Wither-Tip" respectively, has only recently been recognised and carefully studied. The details of the various Brown Rot fungi and their method of attack have been followed with extreme care and minuteness by Dr. H. Wormald, of Wye College, to whom practically the whole of our knowledge of Brown Rots, as they occur on fruit trees in this country, is due, and on whose work this leaflet is based.

The fungus concerned in the various attacks on plums is *Monilia cinerea*, forma *pruni*. It is a form of this same species (*M. cinerea*, forma *mali*) which causes the Blossom-Wilt of apple. The two forms, however, are quite distinct. The plum form is apparently unable to cause Blossom-Wilt of apples and the apple form has not been found on plums. When the number of apple orchards interplanted with plums is considered, this fact should be a matter of considerable satisfaction to growers.

All the photographs used in this leaflet are by Dr. Wormald, and Figs. 2, 3 and 4 are reproduced from the *Annals of Applied Biology*, Vol. V, by kind permission of Dr. Wormald and the Cambridge University Press.

Brown Rot of cherries is caused by the same fungus as Brown Rot of plums, and in this case, also, it attacks the blossom and the wood as well as the fruit. The description given in this leaflet, and also the control measures recommended, would apply equally to cherries.

Blossom-Wilt.—The Brown Rot fungus produces Blossom-Wilt of plums similar to that found on apples (*see* Leaflet 312). In the spring, spores derived from the mummied plums (Fig. 1) on the trees, and from spore-pustules on infected wood, are blown on to the flowers. The spores readily infect the stigma, and the mycelium of the fungus passes down the style and causes the death of the flowers (Figs. 2 and 3). The mycelium subsequently passes through the flower-stalk into the wood and attacks the shoots. Trees which have suffered from Blossom-Wilt may be recognised by the brown, withered leaves which usually remain attached instead of falling off.

The damage caused by Blossom-Wilt is in certain seasons very serious. The factors chiefly contributing to an epidemic attack are a low temperature, and a very moist atmosphere during the flowering period. The former retards the development of the flowers, and causes them to remain susceptible to infection for a longer period than usual, and the latter favours the production (by means of the pustules on mummied fruit and dead wood), of an abundance of spores.

Wither-Tip.—In Wither-Tip the fungus attacks the young green shoots and causes them to die-back. In this way many of the leading shoots are killed (Fig. 4), the buds at the base are then stimulated to precocious development, and instead of fruit buds, a number of weak, ill-ripened shoots are produced.

The Wither-Tip form arises from spores formed on the pustules on mummies, on wood attacked the previous season, and probably also from flowers killed by Blossom-Wilt. It usually commences about the end of April or the beginning of May, when some of the young shoots may be seen to wither. The wilt does not always begin at the tip of the shoot; it may commence some distance down, the fungus in this case entering at a node or through a leaf. Shoots attacked by Wither-Tip hang downwards; at first they are flaccid, but later the tissues harden and dry, and the dead shoots may be recognised by the characteristic curve. The dead brown leaves, being killed prematurely, do not usually fall from the tree, but hang on during winter and even until spring (Fig. 4). When it is a spur that is invaded the fungus sometimes forms a canker similar to that formed in apples.

Spore-pustules develop during the following winter and spring, on all the shoots and spurs which have been killed (Fig. 4, *see* specimen to left, lower part), and these give off spores which provide for the fresh infection in spring. The pustules are small and grey in colour, they commence to show

FIG. 1.—WITHER-TIP AND BROWN ROT OF PLUMS. Mummied plums. The pustules are seen on the centre plum, and are commencing to become active and produce spores.

WITHER-TIP AND BROWN ROT OF PLUMS.

FIG. 2. — Blossom-Wilt. The lower Flower, which was inoculated 5 days previously, shows the style commencing to turn black.

FIG. 3.—The same 9 days after inoculation. The calyx lobes of the lower flower have collapsed and the stamens have withered completely.

FIG. 4.—WITHER-TIP as seen in winter and spring, showing the dead leaves which often remain attached, and the spore-pustules (especially on the shoot to the left).

in December, and increase in number as spring advances. Large quantities of spores are liberated in March, April and May. The fungus in dead twigs may retain its vitality for more than one season and liberate a crop of spores during the second winter after attack. The importance, therefore, of removing such shoots is obvious.

As is the case with Blossom-Wilt, the severity of Wither-Tip is greater in some seasons than in others. Wet, cold weather in spring favours its development, but since epidemics of Wither-Tip have been found to correspond with severe attacks of aphis, it is possible there may be a connection between them. The aphides, by puncturing the leaves, would injure the tissues, and render them particularly susceptible to invasion by the fungus mycelium.

Brown Rot on Fruit.—The fruit is most often attacked when approaching maturity, the slightest wound or bruise allowing the spores to bring about infection. Once it has gained an entrance the mycelium rapidly destroys the fruit, and finally reduces it to the hard, wrinkled structure known as a "mummy." The mummies may fall to the ground, but usually they remain on the tree until spring, stuck together in groups of two or three by means of the fungus mycelium (Fig. 1).

Although it is on ripe or nearly ripe fruit that Brown Rot is best known, it may also attack young fruits. These may be infected by direct contact with mummies or with other diseased fruit, but apart from this it is clear that wounds or abrasions of the surface are necessary for infection. Soon after the fruits are infected, small grey spore-pustules appear, often in concentric rings.* The spores liberated from these pustules infect other fruits. When the fruit is destroyed, and the dry mummy stage is reached, the pustules for the most part cease forming spores and remain dormant till spring, when they regain their activity, liberate myriads of spores, and thus bring about new attacks on the flowers, shoots, and fruits.

Varietal Susceptibility.—With regard to Blossom-Wilt and Wither-Tip, as a general rule, Victoria and Czar Plums suffer most. In 1920 the attack on these varieties in East Anglia was particularly severe, and it was estimated that 80 per cent. of the flowers and shoots were killed in certain districts. Later in the season the trees made new growth, but this was very weak, and on Victoria especially much of it was subsequently killed. Occasionally Monarch Plums suffer more extensively than either of the above. Pond's Seedling and River's Early are not usually so severely attacked.

* It may be noted that Apple Brown Rot (*M. fructigena*) which is distinguished by its buff instead of grey pustules, is sometimes found on *ripe* plums causing a rot. It appears, however, to be confined to such fruit and not to attack flowers or shoots.

The fruit-rot form is common on all varieties, although if trees are extensively affected with Blossom-Wilt and Wither-Tip the likelihood of the fruit becoming attacked by Brown Rot is greater.

Measures of Control.—At present there are three methods of treatment, as indicated below:—

1. *Removal of affected fruits and mummies.*—It cannot be understood too clearly that new infections are mainly brought about by the mummies hanging on the trees, and by diseased twigs. Diseased and decayed plums should therefore be picked and dropped to the ground at the same time as the crop is gathered. Any mummies that are left on the tree should be removed in winter before the buds swell. They should be collected and burned or deeply buried.

2. *Cutting out of diseased shoots.*—As far as possible all dead twigs bearing pustules should be cut out. If the attack is not extensive it will be possible to do this without excessive labour or serious injury to the trees. When large areas are concerned the labour is of course prohibitive, and the trees may be injured through excessive cutting out. At the same time, it should be remembered that the affected wood is quite dead, and therefore useless.

3. *Spraying.*— In spraying the aim is to destroy the spore-pustules on the wood by means of a caustic winter wash, but the treatment is only in an experimental stage. The chief difficulty is to wet the pustules thoroughly, as on account of their powdery nature the spraying fluid runs off. This can partly be overcome by the addition of soft soap. The mixture which has proved most promising is as follows:—

1 lb. caustic soda.
1 lb. soft soap.
10 gal. water.

The best time for applying a winter wash depends to some extent upon the season. It should be applied as late as possible, but not too late to run the risk of damaging the opening buds. Generally speaking, the correct time is about the end of February or the beginning of March, but in a cold, late season the spraying may be delayed until the end of March.

THE DIE-BACK DISEASE OF FRUIT TREES.

(*Cytospora leucostoma* or other species.)

Many varieties of fruit trees in almost every part of the world are subject to a disease characterised chiefly by a dying-back of the branches (*see* Fig. 1). This disease is caused by a fungus named *Cytospora*. Plums, peaches, apricots, apples and cherries (both wild and cultivated) have all been found to be attacked by various species of this fungus. The dying-back, which may extend to the large branches and even cause

FIG. 1.—THE DIE-BACK DISEASE OF FRUIT TREES. Cherry tree suffering from a Die-Back Disease caused by the fungus *Cytospora*.
(From a Photograph by Dr. H. Wormald and reproduced by kind permission of South Eastern Agricultural College, Wye, Kent.)

FIG. 2.—THE DIE-BACK DISEASE OF FRUIT TREES. Portion of diseased wood of Plum Tree showing pustular swellings caused by the fungus *Cytospora*. The spores are extruded in damp weather from these pustules in the form of minute, coiled threads of a reddish colour (nat. size).

the death of entire trees, is common to them all, but as the symptoms vary somewhat, a brief description of the disease as it occurs on the different kinds of trees is given below.

Plums.—Young, vigorous growing trees suffer more often than older ones, the varieties " Victoria," " Czar," " Purple Egg Plum " and " Prince of Wales " being frequently attacked. The first sign of disease is a withering of the leaves, often of a single branch. At the same time areas of bark which may be on the main shoot or on a side branch, collapse and turn brown, and the shoot or branch attacked commences to die back. The dying-back does not as a rule confine itself to the younger branches, but extends downwards and gradually involves the largest branches and the trunk, and may then endanger the life of the tree.

After the branch or main stem has been dead some time, the fungus produces its fructifications which can be recognised externally as pimples or minute pustular swellings in the bark (*see* Fig. 2). The fruit-bodies themselves, which are found within these pustules, soon rupture the bark horizontally and are seen on the surface as more or less elliptical, flattened bodies, white in colour and perforated by one or more pores which appear as black dots. Minute spores, which readily spread the disease, are produced from the pustules in great abundance. In damp weather they are extruded through the spores as minute, coiled, tendril-like threads of a white, pink or reddish colour. This is due to the fact that the spores are held together by a mucilaginous substance. When wetted by rain this substance is dissolved and the individual spores are separated from one another and blown or washed away. The spores may be extruded from the pustules over a period of several weeks but in dry weather spore-liberation is practically at a standstill.*

The conditions under which infection takes place have been carefully examined in the case of the cherry disease, and it has been found that the fungus can only gain entrance to the tree through a wound. If the wound contains no dead wood the injury caused is very slight, but if dead wood is present, the fungus lives upon it first and afterwards invades the living parts killing them as it advances. This is probably true for other fruit trees. Late frosts or other adverse conditions not infrequently cause the death of small branches, or of portions of large ones, whilst careless pruning results in similar injury which lays the tree open to attack. Rank, ill-ripened wood is probably particularly liable to be injured in this way.

* Both on plums and other trees another form of fructification, the ascigerous stage, sometimes develops on the large branches which have been dead for a considerable time. The ascigerous stage belongs either to the genus *Valsa* or *Eutypella* according to the species of *Cytospora* which is present. The previous edition of this leaflet was confined to the two forms of the fungus *Eutypella prunastri*. It is now known that this species is only one of several which cause die-back of fruit trees.

Peaches.—Twigs killed by the disease have at first a dark purplish skin which later becomes leathery and shades into scarlet and purple. The affected areas finally change to a drab colour and the skin becomes loose and wrinkled. Later the spore-pustules of the fungus appear on the affected areas and these exude their spores in minute, tendril-like threads as described above. In Canada the *Cytospora* disease causes severe cankers on the wood, but this type of injury has not been observed in England.

Apples.—In the case of apple trees the disease may start on the branches and spread downwards producing somewhat similar effects to those described for peach trees. The colour of the diseased branches varies from a lightish to a dark purple. Not infrequently, however, in the case of apples, the fungus first attacks the main branches, or even the trunk of the tree near the ground, and produces cankerous wounds. This form of attack is very much more serious than the ordinary form of die-back since the disease extends more rapidly in the tissues, and if the trees are not immediately attended to, they may be completely killed within a year or eighteen months.

Cherries.—Cherry trees attacked by die-back usually show a general yellowing or withering of the leaves, commencing at the tips of the shoots. This may commence in spring and may spread so rapidly (*see* Fig. 2) that by autumn the whole of the upper part of the tree may be dead. When this takes place cracks, from which a viscid gum oozes, often appear in the bark (usually at the crown or at the base of the trunk) and at the same time young shoots arise from the base. On the dead wood the fungus produces spore-pustules abundantly, and in moist weather reddish, tendril-like threads of spores are extruded as in the case of other varieties of fruit trees. The varieties "Noble" and "Napoleon" suffer the most seriously.*

Measures of Control.—1. *Die-back Form.*—If tackled promptly the disease can to a certain extent be controlled. In the case of a die-back, it is of the utmost importance that the diseased portion should be cut away and burned as soon as it is noticed. The longer it is left, the greater is the amount of damage done. The shoot should be cut back to the still healthy region and the wood painted over with tar.

2. *Canker Form.*—Where the fungus has formed cankerous wounds on the main branch or on the trunk, the affected part, if observed early enough, may be cut out with a knife or chisel, taking care to remove all the diseased tissue. As the fungus is a wound parasite, the trees should be damaged as little as

* For details of the disease on cherries *see* Wormald, H., *Jour. South Eastern Agric. College*, Wye, Kent, No. 21, 1912.

possible during these operations; all rough wounds should be pared over with a knife and protected *immediately* with a coating of tar. In order to prevent further spore-liberation great care should be exercised to collect and burn all diseased wood.

3. *Badly Attacked Trees.*—If the disease once obtains a firm hold and the case is beyond recovery, the trees should be taken up at once and the branches cut off and burned to prevent the liberation of further spores.

PEACH LEAF-CURL.

(*Exoascus deformans.*)

Peach leaf-curl attacks peaches, nectarines and, less frequently, almonds; it occurs constantly in this country wherever these plants are grown in the open, but is much less prevalent on trees under glass. The disease is caused by a fungus and, in seasons which favour the fungus, the attack may prove very destructive. It is now known that Peach Leaf-curl *can be controlled effectively by spraying.* There is, therefore, no necessity for the extensive outbreaks which in the past have so often annoyed and baffled the grower of outdoor peaches.

Description of Symptoms.—The disease appears in the spring shortly after the leaves begin to emerge from the bud. The leaf-blade becomes thickened and puckered along the midrib, causing the leaf to become curled and twisted. The diseased part remains yellowish in colour with a tinge of red in it. As the leaves become older, this curling and crumpling of their surface becomes more pronounced, their substance becomes fleshy and the coloration darker; finally the upper surfaces of the diseased leaves become covered with a delicate " bloom " due to the fungus passing into its spore-bearing stage. Affected leaves finally die and drop from the tree, and in severe cases the entire tree may become defoliated. New sets of leaves, however, usually develop and replace those that have fallen.

The fungus not only attacks the leaves but also invades the young shoots and, more rarely, the flowers and fruits. Young shoots infected with the fungus become swollen and twisted and the diseased leaves usually form a tuft on a stunted shoot, owing to the internodes failing to elongate.

In winter, symptoms of fungal activity are visible on the young growth, brown patches being here and there present; these patches increase in size, until finally the whole length of the lateral beyond this point withers and a number of dead ends are left.

The injury caused by the disease consists not only in the distortion of the leaves and premature defoliation but in the

dropping of the fruit at an early stage and in the strain on the tree due to the development of a second crop of leaves. In the case of nursery stock, consecutive attacks for three or four seasons usually kill the tree or stunt its growth to such an extent that it is practically valueless.

Cause of the Disease.—Leaf-curl is caused by an attack of the fungus *Exoascus deformans*. The fungus enters the young leaves early in the spring when the buds are just commencing to expand. The mycelium (or system of fine fungus threads) develops between the cells of the leaf, robbing them of nourishment, destroying the green colouring matter and causing the leaf to become deformed.

After a time the fungus mycelium forms a layer just beneath the skin of the leaf and from this layer a number of spore-sacs (termed asci) are developed; it is their presence which causes the "bloom" upon a diseased leaf. Within each of these spore-sacs eight spores are produced and these spores usually bud off a number of secondary spores, all of which are capable of germination and reproducing the disease. The spores are produced in great abundance upon the diseased leaves during the spring and early summer.

Commencement of Attack in Spring.—It was long believed that the fungus mycelium hibernated in the tissues of affected shoots and during the succeeding spring grew up into the expanding leaflets and produced disease. Later observation, however, has shown that this is of comparatively rare occurrence. Such facts as are at present available tend to show that fresh infection of the leaves in the spring always takes place by means of spores which have lain dormant during the intervening months, entangled among the scales upon the buds.

The establishment of a new outbreak of disease by these spores is intimately connected with the weather conditions which prevail at the time. Cold, wet weather, when the leaves are expanding, causes them to become abnormally gorged with water and much more susceptible to an attack by the fungus. It is a widely observed fact that leaf-curl is very much less prevalent in a uniformly warm and dry spring; it has also been noticed that where infection has occurred a return of warm, dry weather, or even the occurrence of a hot, dry wind will check the development of the fungus within the tissues. Peach trees planted near large expanses of water, where the atmosphere is moister and cooler than elsewhere, have been found to be especially liable to the disease.

Measures of Control.—There is only one method of controlling leaf-curl, that is, by spraying. The fact that, if

Photo.] [*F. O. Mosley.*

PEACH LEAF-CURL.

AMERICAN GOOSEBERRY MILDEW.

FIGS. 1 and 2.—White or summer stage on young shoot and leaves.

FIG. 3.—Summer stage on berries, passing gradually into the brown stage.

FIG. 4.—Shoot showing brown felt of mycelium or winter stage.

FIG. 5.—Portion of the same, magnified about four times, showing minute spore cases embedded in the felt of mycelium.

the affected leaves are picked off, a crop of new, clean growth is produced, has led some persons to assume that the removal of the curled foliage will eradicate the disease. This is not the case. The summer growth is always clean and, unless the plants are sprayed in February or March as described below, leaf-curl will develop again in the following season.

The secret of success is to spray early, immediately before the buds begin to swell. This time will range between the middle or latter part of February and the beginning of March, according to the locality and the nature of the season. Burgundy or Bordeaux mixtures may be used.

1. *Burgundy Mixture.*—A Burgundy mixture of the following composition has been used with excellent results at the Royal Horticultural Society Gardens, Wisley*:—

Copper Sulphate	2½ lb.
Sodium Carbonate	2¾ lb.
Water	12 gallons.†

The copper sulphate (98 per cent. purity) and the sodium carbonate should be dissolved in separate wooden vessels, and mixed together when completely dissolved.* One spraying, just before the buds open, is usually sufficient, but a second spraying a few days later gives additional assurance of success. Great care should be exercised to see that the buds are completely coated with a film of the mixture. Before spraying, all dead twigs and any obviously diseased shoots should be cut away.

2. *Bordeaux Mixture.*—Bordeaux gives more trouble to prepare than Burgundy mixture, but if preferred the following proportions are recommended:—

Copper Sulphate	13 oz.
Best Quicklime	13 oz.
Water	10 gallons.

The copper sulphate should be dissolved in water at the rate of about 13 oz. to 1 gallon. This should be done in a *wooden* receptacle. The lime should be slaked to a fine powder with a little water in another receptacle. Water should be added gradually to make a " milk " and then diluted to the amount required (9 gallons), stirring well throughout. Finally, the copper sulphate should be poured into the diluted milk of lime and stirred thoroughly for 5 minutes. The mixture should be used within 24 hours and, preferably, as soon as made.

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* *See* Horne, A. S., *Jour. Roy. Hort. Soc.*, Vol. XLI (1915), pp. 110-115.

† If a smaller quantity of the mixture be required, the proportions would be :—

Copper Sulphate	9¾ oz.
Sodium Carbonate	11 oz.
Water	3 gallons.

At Wisley, the addition of a small quantity of milk to the above mixture was found to be of advantage in facilitating the adherence of the spray to the buds.

AMERICAN GOOSEBERRY MILDEW.

(*Sphaerotheca mors-uvae*, Berk.)

The serious disease known as American Gooseberry Mildew was introduced into Europe in 1900, and has since spread throughout the Continent. This mildew, which is known technically under the name of *Sphaerotheca mors-uvae*, has greatly interfered with gooseberry growing, and in some countries it has rendered the cultivation of this fruit quite unprofitable. It has also been found on red and black currants, but only rarely. Few diseases have been more carefully investigated in this country, and, though much remains to be learned, it is now possible very largely to control its ravages.

Description of the Disease.—There are two well-marked stages in the life-history of the mildew which it is important to distinguish, namely, a white and a brown stage. The white stage always comes first on the new season's growth, but it is often of short duration and may pass into the brown stage so rapidly that it is the latter which sometimes first attracts attention.

The first stage appears in the form of powdery white patches of mildew on the berries, shoots and under-sides of the young leaves (*see* Figs. 1, 2 and 3).* This stage may occur at any time from April to October, and is consequently often referred to as the summer stage. Whilst in this form the mildew produces vast quantities of minute spores which are readily scattered, and, germinating at once, produce fresh spots of mildew on any young growth on which they may alight. In this way the mildew is very rapidly distributed. Suckers and other soft, quick-growing shoots, on bushes which have been highly manured or grown upon deep porous soils containing an abundance of moisture are particularly liable to be attacked.

The brown stage is a subsequent development of the white stage, and occurs abundantly on the shoots and berries, less often on the leaves (*see* Figs. 3 and 4). It takes the form of a thin felt which can be peeled off easily with a knife or with the finger nail. The felt consists of fine threads of rusty brown fungus mycelium, and embedded in it will be found almost invariably, minute spore-cases known as perithecia, each of which contains a single bladder-like sac within which eight spores are normally to be found. The perithecia are just visible to the naked eye as minute black specks (*see* Fig. 5).

The perithecia are produced during the course of the summer and autumn. It is known that some of them burst

* This serves to distinguish it from the very much less serious disease known as European Gooseberry Mildew, in which almost invariably the leaves only, and chiefly the old ones, are affected. (*See* Leaflet No. 52.)

and discharge their spores before the end of the season; and, as a result, fresh infections may arise. Most of the perithecia, however, remain dormant over the winter. They liberate their spores in the spring and thus constitute the source from which fresh outbreaks arise each season. Most of the perithecia remain attached to the rusty, felted mycelium on the twigs during the winter, but many of them fall off and reach the soil. It is believed that infection may arise in spring from the latter as well as from the former.

Measures of Control.—There are two principal lines of treatment against American Gooseberry Mildew: (1) spraying, to prevent the outbreak of the white or summer stage and to destroy it should it appear; (2) tipping, to eliminate the brown stage with its perithecia. In addition, it need hardly be said that all possible measures should be taken to prevent the disease from gaining access to areas not affected.

1. *Spraying.*—For spring and summer spraying lime-sulphur is the most convenient and satisfactory substance. It can be bought ready-made in concentrated form in drums at a moderate price, and for use only needs diluting to the proper strength. In purchasing, however, a guarantee should be obtained that the lime-sulphur is of 1·3 specific gravity. The strength hitherto recommended is 1 gallon of concentrated lime-sulphur to 29 gallons of water. When required for use, the lime-sulphur should be poured slowly into the water, and after being well stirred, the mixture should be applied at once.*

Three, or at least two, sprayings should be given. The first, which is intended to give the bushes a fungicidal covering to prevent infection, should be made about the first week in April, the exact time will depend upon the district and the nature of the season. The two remaining applications, which are either preventive or have as their object the actual destruction of the summer stage, should be given at intervals of three or four weeks. Every care should be taken to wet the leaves thoroughly on both sides with the spray. If only two applications can be given, the last of the three sprayings should be the one omitted.

It has been found that the following varieties of gooseberries are apt to be damaged by lime-sulphur if used at the strength mentioned above:—Berry's Early (Keepsake), Cousin's Seedling, Lancashire Lad, Crown Bob. In these cases a wash of one-half the usual strength should be employed, viz., 1 gallon of concentrated lime-sulphur to 59 gallons of water. Some commercial growers, indeed, use

* It should be remembered that the sulphides in the lime-sulphur and ammonium polysulphide washes react with copper, hence spraying machines with copper parts should never be used with these mixtures, unless the parts with which the liquid comes into contact are tinned.

this half-strengh solution as their standard wash with economy and success.

A few kinds cannot safely be sprayed with lime-sulphur at all. These are chiefly the sulphur varieties, which include Golden Drop (Yellow Rough).

An objection to the use of lime-sulphur for the later sprayings is that it leaves a deposit on the berries which, although not poisonous, detracts from the commercial value of the fruit. This deposit may be removed by mechanically rubbing the berries against each other in water, or by passing them through a "Gooseberry Cleaner."

Messrs. Eyre and Salmon recommend an ammonium polysulphide wash for the last spraying,* since this fluid leaves no visible deposit on the sprayed parts, and is, therefore, useful for application to dessert varieties. The stock solution of ammonium polysulphide, which should be bought ready-made, is diluted with water as directed so as to contain 0·11 per cent. of polysulphide sulphur. With this wash, which is known as the A.P.S. wash, 0·5 per cent. soft soap (=5 lb. of soft soap to 100 gallons of wash) should be used.

2. *Tipping.*—"Tipping" consists in the cutting away in autumn of all shoots which show signs of the presence of mildew. The operation should be carried out as soon as possible after the wood is ripened, since, as explained already, many perithecia fall off the shoots during late autumn and winter. On the other hand, it should not be commenced before active growth has ceased, otherwise the bushes will produce fresh shoots, the soft tips of which are particularly liable to infection with mildew. Late August or early September is usually the most suitable time, but the exact date will vary with the season, the age of the bush and the locality. On no account should the tippings be allowed to fall to the ground; as the work proceeds they should be carefully collected and burned. Tipping may not be a sound economic proposition in large commercial plantations, especially if the mildew has become thoroughly established. But in mild attacks and in new outbreaks tipping, if thoroughly carried out, undoubtedly serves very materially in reducing the amount of infection in the succeeding spring. It need hardly be added that there is no need to tip parts of bushes that are not diseased or to tip healthy bushes.

3. *Other Precautionary Measures.*—Gooseberry bushes should not be purchased unless a guarantee is given that they are free from American Gooseberry Mildew.

If the disease is known to be present in the neighbourhood, special precautions should be taken to prevent its spread. Baskets, packing-cases, or empties likely to be contaminated

* *See Journal Ministry of Agriculture*, Vol. XXII, Feb., 1916, pp. 1118-1125; Vol. XXIII, Feb., 1917, pp. 1098-1100; Vol. XXV., Mar., 1919, pp. 1494-1497; Vol. XXVI, Nov., 1919, pp. 821, 822.

with spores should not be allowed on the premises, unless they have been disinfected by washing in a solution of copper sulphate (1 lb. copper sulphate to 20 gallons of water). The clothes of workers and pickers are also liable to become contaminated with spores; if pickers, therefore, proceed from an affected plantation to a healthy one they are liable to be the means of spreading the disease. Periodical inspections of the bushes should be made once a month from May to September.

Legislation.—Under the American Gooseberry Mildew Order of 1919, notification of the disease is required only from persons who grow gooseberry or currant bushes for sale, but the Ministry retains power under the Order to deal with fruit growers and private owners who fail to take proper steps to check the disease. Such notification must be made to the Ministry of Agriculture and Fisheries, or to an Inspector of the Ministry. It is illegal to sell gooseberry or currant bushes affected with the disease, but the bushes may be sold after notification if all the diseased shoots are cut away.

There are no other restrictions on the movement of gooseberry and currant bushes.

Article 6 of this Order, and all previous Orders relating to the sale of gooseberries (fruit) affected with this disease, are now revoked, so that any gooseberries fit for human consumption may be sold in all markets and shops.

The importation of gooseberry and currant bushes and of gooseberries (fruit) into England and Wales, from any place abroad other than the Channel Islands, is permitted provided they are accompanied by a certificate issued by the exporting country to the effect that they are healthy and free from disease. (Destructive Insects and Pests Order of 1922.)

Further information with regard to either of these Orders can be obtained on application to the Ministry of Agriculture and Fisheries.

EUROPEAN GOOSEBERRY MILDEW.

(*Microsphaera grossulariae*, Lév.)

The gooseberry plant is attacked by two distinct mildews, termed respectively the European Gooseberry Mildew and the American Gooseberry Mildew. The former, caused by the fungus *Microsphaera grossulariae* is the only one dealt with in the present leaflet. The latter, caused by an entirely different fungus, is a very much more serious pest and will be found described in Leaflet No. 195.

The two mildews, though somewhat similar in certain stages, can with a little experience usually be distinguished even with the naked eye. The European Gooseberry Mil-

dew occurs on the upper side of the leaves in the form of a very delicate white mould or mildew. In the early stages it is coated with a distinctly mealy substance. As is the case with all true mildews the *mycelium* (spawn) is quite superficial, although, in order to obtain the nourishment it requires, the fungus sends down minute suckers into the cells of the attacked leaf. The white mealy substance consists of masses of spores. These spores are termed *conidia* or " summer spores," and, being carried by insects or being blown about by the wind, bring about the infection of other leaves. As a rule the mildew is confined to the upper surface of the leaf, but occasionally it is found on the under surface and also on the berries.

Later in the season the fungus produces a second form of fruit. These consist of minute spherical spore-cases (*perithecia*) which contain the " winter spores " or " resting spores." They occur on the mildewed patches and appear first as yellow specks just visible to the naked eye, but ultimately become black. In autumn the spore-cases either fall off the leaves or fall to the ground with the leaves. They remain dormant during the whole winter. In spring the spores are liberated and shot out into the air. They are blown by the wind on to the new leaves just unfolding and infection results. The delicate white mould soon appears and a crop of summer spores follows in a few days. From these " primary " infections, new or " secondary " infections take place and thus in favourable weather the mildew spreads rapidly.

European Gooseberry Mildew may occur as early as May and lasts throughout the season. It is widely distributed and as a rule causes but little damage; it is mostly found under heavy shade and on old bushes. When the attack is severe the leaves die, and fall off early in the season; the fruit as a result is checked in its growth and remains small. If a severe attack follows for several seasons in succession the bushes become stunted and may even be killed. Red currants are also occasionally attacked by European Gooseberry Mildew.

The most obvious differences between the present disease and the American Gooseberry Mildew may be summed up as follows. Whereas in the European Gooseberry Mildew the fungus occurs as a very delicate mould or mildew on the leaves, the American Mildew forms a dense white woolly mould which, though found on the leaves, attacks chiefly the shoots and berries. As the growth of the American Mildew continues the white stage gives place to a light brown woolly phase and finally to a thin dark-brown felted mat, which is very conspicuous on the berries and shoots. This condition is never found in European Gooseberry Mildew, where the mildew always remains thin and scanty. The resting-spore

fruits, moreover, are in the European Mildew found exposed on the leaves, whereas in the American Mildew they are embedded in the felt on the shoots and berries. Occasionally the two mildews are found on the same plant.

Measures of Control.—European Gooseberry Mildew can be controlled by spraying. If the amount present is small it will hardly be necessary to resort to this treatment, but if the attack is severe, or if from previous experience a bad outbreak of mildew may be expected, it will be advisable to spray occasionally with lime sulphur. The first application should be given early in May and at the rate of 1 part lime sulphur to 60 parts water.

The ground under diseased bushes should be dug over in winter in order to bury the winter spores, and if only a few bushes are grown the additional precaution may be taken of collecting and burning in autumn the dead and fallen diseased leaves.

CORAL SPOT.

(*Nectria cinnabarina.*)

No fungus is perhaps more plentiful on dead twigs and branches and more familiar to every gardener than the Coral Spot fungus, *Nectria cinnabarina*. It is abundant and conspicuous in damp weather on dead branches of elm, lime, poplar, sycamore and many other trees, and is always to be noted plentifully on old pea sticks, particularly hazel, in autumn and winter. In these dead branches the fungus occurs in the condition known as saprophytic, *i.e.*, living on dead or decaying material, but though it usually occurs as a saprophyte it not infrequently becomes parasitic, that is, it invades living tissues. In this form it attacks trees of many kinds, ornamental shrubs and bush fruits, of which lime, sycamore, horse chestnut, apple and currant may be mentioned as being more particularly susceptible. The present leaflet deals specially with its attack on fruit trees, though the general remedial measures recommended apply equally to other plants.

The Coral Spot fungus may be recognised by the small pink or flesh-coloured warts which are thickly scattered over the surface of the dead and dying branches. The warts are in reality spore-pustules which consist of fungus filaments bearing masses of spores. In damp weather the pustules are slimy and salmon coloured, in dry weather they are powdery and pale pink in colour.

Method of Attack.—On fruit trees Coral Spot is particularly common on red and black currant and gooseberry, but it also attacks apples and pears. In all these cases it attacks

the plants in one or other of two ways; either by commencing on the dead twigs and working from them into the living tissues or, more rarely, by gaining entrance by means of a wound to the stems or branches lower down.

In red currants the evidence suggests that by far the largest amount of infection occurs through small branches which have died back. The fungus spreads from these dead shoots into the main healthy branches, causing them to wilt. This wilting occurs in May and June and is a very conspicuous feature of badly affected plants.* The fungus probably obtains entrance in a similar way in the case of gooseberries.

In young apples cases have been observed where, owing to rank grass and weeds having been allowed to grow round the stems, the Coral Spot fungus gained an entrance through dead branches or wounds near the ground level and caused the death of the entire trees.

The effect of the fungus filaments within the tissues is to cause the gradual death of the branch. In the case of its ally, the Apple Canker fungus, *Nectria galligena* (*see* Leaflet No. 56), the tree resists the parasite, forming a callus, and a canker-wound is the result. No callus formation takes place in Coral Spot. The mycelium invades the woody portion of the stem and kills and blocks up the water-conducting tissues. It is not surprising, therefore, that in bush fruits such as currants the death of the attacked branches should follow sooner or later. Wood which has been destroyed by the Coral Spot fungus turns first dark green or black and then brown. In the case of apples (as also in trees such as sycamore and horse chestnut) larger branches may be attacked with equally fatal consequences. Soon after the tissues are killed the fungus commences to form spores, these being borne in amazing quantities on the pink pustules above referred to. These spores are very minute and are termed *conidia* (conidia meaning dust-like) and are developed all the year round. Another form of spore is, however, also produced, chiefly during spring, and especially on the larger branches. These spores are formed in dark red bodies named *perithecia* and are usually borne on the site of old conidial pustules. The perithecia are comparable in function to those so well-known in American Gooseberry Mildew.

Measures of Control.—1. *Prevention.*—It has been shown that the fungus gains entrance in two ways, viz., through dead branches and through wounds. All dead shoots and branches should therefore be removed during pruning and care taken that no snags which will die back are left. Injury

* For information as to Red Currants the Ministry is indebted to Mr. F. T. Brooks, of Cambridge University, who has this disease under investigation.

to bushes should also be avoided whether in pruning or in cultivation with the hoe. Wounded surfaces should be protected by tar.

2. *Treatment of Attacked Trees.*—The disease may often be arrested by the rigorous use of the knife. Diseased branches should be cut clean out, taking care to cut back to healthy wood and to protect the wound. In the case of large boughs, if the attack is dealt with early, it may be possible to save the branch by removing the infected area with a knife or chisel. Great care must be taken to remove all the affected tissue and to tar the wounds.

3. *Sanitation.*—Accumulations of dead wood and sticks should never be allowed in an orchard. On such débris fungi of all sorts flourish, including those causing Coral Spot, Silver Leaf, Canker and other dangerous diseases, and from these fungi millions of spores are liberated into the air and blown amongst the trees. The better the sanitary condition of the orchard, the less the chances of infection by fungus parasites.

THE DIE-BACK DISEASE OF GOOSEBERRIES

(*Botrytis cinerea.*)

The Die-back of Gooseberries is a disease very widespread in England and one liable to occur wherever these bushes are grown, whether in large plantations or in small gardens. Although gooseberries may die-back from various causes, in many cases the serious attacks which occur are found to be due to the minute fungus *Botrytis cinerea*. This fungus is exceedingly common as a saprophyte on decaying vegetation, but, under certain conditions, it becomes parasitic and attacks living plants. The present leaflet is confined to the disease caused by *Botrytis*.

Description of the Disease.—The gooseberry bush may be attacked by *Botrytis* in four distinct places, viz., (*a*) the main stem and base of the branches, (*b*) the young wood of the current year, (*c*) the leaves, or (*d*) the berries.

(*a*) *The Main Stem.*—As regards the main stem, the mycelium (spawn) of the fungus penetrates the outer tissues, and at the end of the season causes the bark to crack and peel off, often in large pieces. The part of the stem first attacked is usually that portion situated at the ground level or a little above it; the fungus kills the wood and eventually "rings" the stem at this place and the whole bush is killed. Before this occurs, however—and, in the case of a well-grown bush, death does not as a rule result for several seasons—the

This leaflet is based on work carried out by Mr. E. S. Salmon, of Wye, and the illustrations are reproduced from the *Journal of the South Eastern Agricultural College*, Wye, Kent, No. 18, (1909), by kind permission of the College authorities.

mycelium of the fungus spreads upward in the stem to the base of the branches. Here it frequently attacks some of the branches so severely that they die.

Renewed growth of the mycelium of the fungus in the stem takes place every spring, and it is then that the manner in which the fungus exists and spreads can be most easily seen. If a diseased stem be examined during a warm and damp spell of weather in the spring, the appearance shown in Fig. 1 will be observed. The bark will be found to be peeling or cracking off, while greyish, fluffy patches of a "mould" have appeared at the edges of the peeling bark or in the fissures where the bark is cracked. If there is a dead branch on the bush, as a rule, small greyish tufts or little cushions—which soon develop in suitable weather into fluffy patches such as are shown in Fig. 2—will be found scattered here and there over its surface. These tufts of the fungus occur both on the main branches nearly down to their base (*see* Fig. 3), and frequently also on the younger wood.

Small hard, blackish bodies, of irregular shape, named *sclerotia* are also produced in the bark. They are the resting bodies of the fungus and on subsequent germination give rise to multitudes of spores which spread the disease. They are extremely resistant to climatic conditions such as frost, drought, &c., and serve to carry the fungus through all vicissitudes from one growing season to the next.

(*b*) *The Young Wood.*—In the case of young bushes especially, a considerable proportion of the young shoots may be affected by *Botrytis* and much weakened or killed—a fact which has caused growers to speak of the disease as "die-back" (*see* Fig. 4). The dead shoots may constitute a prolific source of infection. Prunings of *Botrytis*-affected bushes left lying in a heap in a corner of the plantation or garden may develop during the following spring an abundant crop of powdery tufts of *Botrytis*, the spores of which, carried by the wind in countless numbers, will spread the disease through the plantation. There is also the danger of cuttings having been taken from *Botrytis*-infected bushes, when many of the young bushes resulting therefrom will become diseased.

(*c*) *The Leaves.*—Very commonly *Botrytis* infects the leaves, which soon become discoloured at their edges, at first turning yellowish, and finally ashy-grey or whitish (*see* Fig. 3). If the attack extends from the edge of the leaf inwards until the greater part of the leaf is affected the fall of the leaf soon takes place; if, however, as is often the case, the injury remains restricted to the edges of the leaves, they remain on the bush until they drop in the normal way. Whether the injury spreads over the leaf to such an extent as to make it fall prematurely seems to depend on the climatic conditions which prevail at the time.

THE DIE-BACK DISEASE OF GOOSEBERRIES.

FIG. 1.—Portion of stem (just above ground level) of a gooseberry bush attacked by *Botrytis*; fructifications of the fungus can be seen appearing between the cracks of the bark.

FIG. 2.—Part of an old diseased branch; compact cushion-like tufts of *Botrytis* (x) have been formed on its surface.

THE DIE-BACK DISEASE OF GOOSEBERRIES.

FIG. 3.—Shoot of "Whinham's Industry," with the leaves attacked at the edges by *Botrytis*.

FIG. 4.—Two shoots of "Whinham's Industry," showing the leaves affected more severely, and a young shoot (*to right*) killed by the fungus.

(*d*) *The Berries.*—Lastly, the fungus occasionally attacks the berries and causes them to rot. The first sign of disease on the berry is the browning of the skin; this browning gradually extends until one side of the berry shows obvious signs of softening and of being badly diseased. The *Botrytis* fructification, in the form of the characteristic ashy-grey "mould," then appears on the surface of the discoloured portions and in about a week the berry becomes completely rotten.

Measures of Control.—1. *Sanitation.*—The most effective treatment is to remove and burn all dead bushes or branches in the plantation. As soon as the edges of the leaves show signs of discoloration, all the bushes in the plantation should be examined and any found with the main stem diseased should be grubbed up and burned. This treatment, carried out for a few seasons, has proved more efficacious than spraying.

It must not be forgotten that the fungus is capable of developing vigorously on *dead* parts of the bush. In nearly all cases the disease appears first either on single plants scattered here and there through the plantation, or on several bushes over a small patch of ground, while the surrounding bushes are healthy. If the disease on its first appearance is dealt with summarily by the burning of all dead bushes and branches, there is no need to spray or to take any other remedial measure.

2. *Spraying.*—Where the disease is severe and widespread spraying must be resorted to in addition. A heavy spraying with a solution of copper sulphate (4 lb. dissolved in 100 gallons of water) should be given *just before the buds burst*, care being taken to spray thoroughly the main stems of the bushes. The infection of the leaves may be prevented by spraying, *directly the fruit is set*, with Bordeaux mixture composed of 8 lb. copper sulphate, 8 lb. quicklime, and 100 gallons of water (for the preparation of this mixture, *see* Leaflet No. 131). It is essential that the under-surface of the leaves should be reached as much as possible. No injury follows the application of Bordeaux mixture of this strength, and if the spraying be done at the time indicated, no spotting of the berries occurs.

3. *Cultivation**.—It may finally be noted that any treatment which induces the bushes to make vigorous growth tends to stop the attacks of the fungus. This treatment will chiefly consist in the keeping down of weeds, the cutting-out of old and superfluous growth and attention to soil conditions. The gooseberry responds to good treatment in the

* See Leaflet No. 346. *Gooseberry Growing*, included in Sectional Volume No. 4, "*Fruit : Its Cultivation, Marketing and Preservation*," price 1s. 6d., post free.

shape of manuring but is very dependent on the presence of lime in the soil, and strongly resents soil acidity. Lime, therefore, should be applied if necessary. If there is any evidence that potash is deficient, a dressing of 1 cwt. sulphate of potash per acre should be given. It is well known that diseases make more headway where there is an excessive supply of nitrogen or lack of potash.

POWDERY MILDEW OF THE VINE.

(*Uncinula necator*, Burr.)

The vine is subject to two very serious forms of Mildew, the one a member of the group of Powdery Mildews caused by the fungus *Uncinula necator*, and the other, one of the Downy Mildews, induced by the fungus *Plasmopora viticola*. Both these fungi have been recorded for Britain, but the latter is exceedingly rare and is not dealt with in this leaflet.

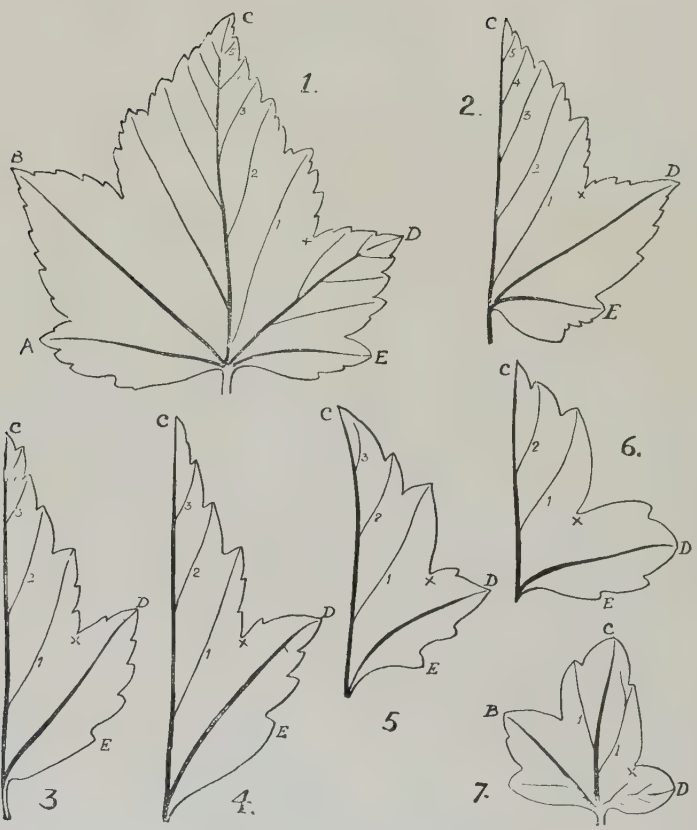
The Powdery Mildew fungus is now believed to be a native of Eastern Asia. It was first observed in Europe in 1845; appearing in England near Margate that year, and very soon after in the vineyards of France, Spain and Italy, where it spread rapidly and caused enormous devastation. Since then it has spread to practically all the large vine-growing countries and has caused much damage to cultivated vines both in the Old and New Worlds.

Powdery Mildew is the common vine mildew familiar to every vine grower in England as giving trouble both under glass and in the open. It can now be completely controlled under glass, and with due care and attention can be very largely held in check on outdoor vines.

Description.—The appearance of the disease being so well known hardly requires description. The fungus attacks the young shoots forming white patches of fungus threads (mycelium) on young leaves and shoots. As in the case of other Powdery Mildews the mycelium is superficial, and merely sends down minute suckers in order to extract nourishment. In spite of this, however, great damage is done, and the foliage is often crippled and sometimes killed. On this same mycelium spores are produced in enormous numbers. They are exceedingly minute and are readily blown about. They occur in such profusion that the masses of spores are visible on the leaf as a white mealy powder.

In addition to the foliage the fungus also attacks the flowers and fruits. This causes the fall of the flowers and also of the fruits if still quite young. If the fruits are attacked at a later stage the fungus may cause distortion and cracking of the berries, thus rendering them useless. No new infection takes place after the grapes have begun to ripen.

Powdery Mildew of the Vine.—Diseased Leaf and Grapes.



"Reversion" in Black Currants.

Figs. 1 to 7.—Progressive stages of the disease, from a normal leaf in Fig. 1, to the oak-leaved form in Fig. 7. The main veins are marked A, B, C, D, E, and the sub-main veins, which spring from C and are the important ones for purposes of identification, are indicated by numbers.

The mildew usually commences about the time the grapes are in flower, and continues to spread through the whole growing season. In America and certain other countries it forms resting spores in autumn which provide for the fresh outbreak of the Mildew in spring, but in Europe this form of over-wintering is practically non-existent and the fungus hibernates by means of mycelium in the buds.

Measures of Control.—1. *Outside.*—Where vines are grown extensively in the open the selection of a well drained site and of one in which the vines have abundance of sun and air will do much to minimise mildew attacks. Another point of great importance is to plant the vines well apart and to pinch the laterals back carefully in summer to prevent crowding.

Both on the Continent and in America Powdery Mildew in the open is largely controlled by the use of flowers of sulphur or other fine sulphur-powder. This should be applied by means of a sulphur bellows or sulphurator and is best put on early in the morning when the foliage is damp. It is possible that a lime sulphur solution such as is used for American Gooseberry Mildew (*see* Leaflet No. 195) may be useful, but no records as to the use of this fungicide for vine mildew are available. Bordeaux Mixture, although used with success on the Continent for the other vine mildew (Downy Mildew), is not regarded as satisfactory for keeping down Powdery Mildew.

2. *Under glass.*—Mildew may very largely be *prevented* by careful attention to cultural details. The atmospheric conditions of the house, which to a great extent can be controlled by careful ventilation, are most important. Air should be given early and gradually increased as the temperature rises; draughts should always be avoided. During dull, wet periods a buoyant atmosphere should be maintained by increased fire heat and by giving some ventilation for at least a short period of the day. The same or even more care should be exercised as in the open with regard to the thinning out and pinching back of laterals so that plenty of light and air are admitted. The maintenance of a steady temperature and the avoidance of dryness at the root also tend to prevent mildew from obtaining a footing.

If mildew appears sulphur should at once be applied. The safest method is to blow a fine sulphur powder on to the foliage by means of a sulphurator. The old fashioned plan of painting the hot water pipes with a mixture of milk and sulphur and then heating them steadily for a few hours is effective, but the work should be entrusted only to an experienced hand. By far *the most effective method* is the use of the apparatus known as a Sulphur Vaporizer. With this apparatus Vine Mildew can be completely suppressed, but here again great caution is needed and the instructions accompanying the vaporizer should

be strictly attended to. In the case of these last two methods, any ferns and other plants with delicate foliage which are present in the house should be removed during the vaporizing operation.

"REVERSION" OR NETTLEHEAD OF BLACK CURRANTS.

(Cause Unknown.)

Introduction.—One of the most serious diseases of Black Currants at the present time is that termed "Nettlehead" or "Reversion." Owing to its ravages hundreds of acres of Black Currants have ceased to bear as they did formerly and many have become so unprofitable that the bushes have been grubbed up. The precise nature and cause of the disease are still obscure. It does not represent reversion in the strict sense of reverting to a previous type. It is apparently not caused by any fungus, and insects are not directly responsible, though possibly their attacks may not be altogether unconnected with it. In spite of this unsatisfactory state of knowledge, it is felt that the issue of a leaflet on the subject is justified, not only to enlighten those not fully aware of the existence of "Reversion," but to point out measures which will help to prevent further spread of the trouble. The disease has been studied for many years by Mr. A. H. Lees of the Long Ashton Research Station, and much of the information given in this leaflet is based on an article by him which appeared in the Ministry's *Journal* for March, 1921. It should be clearly understood that the account given below does not profess to be final, and that with continued research further information may be early expected.

Description of the Disease.—*General Characters.*—"Reversion" shows itself in several ways. (1) The most obvious symptom is the change in the character of the leaves, which become elongated and narrow and often assume the "nettlehead" form, as is described more fully below. (2) There is a progressive change, as the trouble develops, in the form of flower-truss and in the flowers themselves. (3) There is ultimately an almost complete failure to produce fruit. It should be clearly understood, however, that "Reversion" is quite distinct from the trouble known as "Running-off" which occurs on perfectly healthy bushes. This is a very widely-spread phenomenon and is often mistaken for "Reversion." In an important paper recently published* it is shown that

* The "Running-off" of Black Currants: R. Wellington, R. G. Hatton and J. Amos, *Jour. Pomology*, Vol. II, No. 3.

" running-off " on healthy bushes is due to ineffective pollination. When such bushes are effectively pollinated, either by artificial means or by natural agencies, a full crop of fruit is produced, given normal conditions. In " Reversion " the flowers become more or less abnormal in structure and artificial pollination completely fails to produce a crop.

Leaf Characters.—With regard to the leaves, although the general appearance of " reverted " foliage was familiar to all growers, the precise symptoms by which one could detect them with certainty were not clearly grasped. The method of identification described by Mr. Lees is based on the fact that the number of sub-main veins and marginal teeth are fewer in " reverted " leaves, the decrease being small in slightly " reverted " leaves and great in those which are badly attacked. The examination should be confined to strong new shoots, as spur leaves are apt to be unreliable. The successive stages are found in the illustrations, No. 1 being a normal leaf and No. 7 a very badly diseased one. It will be seen that in the normal leaf there are five main veins, A, B, C, D, E, and these run from the top of the leaf stalk to a point at the margin.* From the middle main vein, or midrib C, a series of sub-main veins run to points on the margin and it is the number of these sub-main veins which provides one indication of the degree of " Reversion." If less than five are present the leaf is " reverted," if five or more the leaf is probably normal. For further details the reader is referred to the paper quoted.

The second indication is afforded by the leaf margin. If finely-toothed with 4 to 8 teeth between C and X not receiving a sub-main vein, the leaf is almost certainly normal, but if coarsely-toothed, with less than four fine teeth not receiving sub-main veins, the leaf is to some degree " reverted." (The maximum number of unveined teeth on a healthy leaf probably varies with the variety.) In leaf No. 4, which shows a medium stage of " Reversion " and one which is of common occurrence, the sub-main veins are reduced to three and many of the teeth have disappeared. In No. 5 there is a further reduction and in No. 7 the extreme or " Oak-leaved " type is reached.

Identification by shape and size is less certain. " Reverted " leaves are usually small and often long and narrow, but not always so. If, for instance, a " reverted " bush grown under good cultural conditions be cut to the ground, the following season's growth has quite large leaves which at first sight appear to be also almost normal in shape, but their " reverted " character is quickly revealed by the method outlined above. Conversely, small leaves are not necessarily " reverted," such leaves, quite normal in character, being produced

* For the sake of convenience only half of the leaf is shown in these illustrations, but the amount of reduction is the same on both halves of the leaf.

frequently, both at the beginning and at the end of the growing period.

Date at which Inspection should be made.—It is important to note the season during which " Reversion " may be best detected. A diseased bush may start growth by producing normal leaves; but soon after (about the middle of May at Long Ashton) the " reverted " leaves begin to appear and they continue to develop to the end of June. Additional leaves of this type may develop later, but very often the foliage produced in July and August is very much less " reverted " and, by overtopping the badly affected leaves, is more conspicuous. No attempt to identify the disease should be made early in the season. May and June are the best months and if it is desired to do the work after this period, the shoots should be turned back and the May and June leaves examined.

It should be noted finally that the whole bush does not necessarily become affected at the same time. The bushes may " revert " by degrees, branch by branch becoming affected. This fact is of great importance when selecting bushes for propagation as described in the next paragraph. To be absolutely safe every branch should be examined.

Measures of Control.—Two methods only can be recommended at present, namely, care in propagating from sound stock and rogueing of the beds. By strict attention to these precautions at least one large grower has practically eliminated the disease from his plantations.

1. *Propagation from Sound Stock.*—To secure this the stock should be gone over in June and those plants marked which are absolutely healthy. Plants should not be marked in groups, but an individual examination of each plant should be made. It is best to err on the safe side by marking only bushes which are beyond suspicion.

2. *Rogueing.*—In June each year the cutting beds should be gone over and every affected bush grubbed up and burned. The same procedure should be adopted in the plantation except that, as the bushes are fruiting, they should be marked and reserved for destruction after the fruit is picked.

CONCLUSION.

In addition to the diseases dealt with in the foregoing pages fruit trees are attacked by a large number of other fungi and also by certain diseases the causes of which are unknown. Some of the latter such as Bitter Pit may be very serious but up to the present so little is known either as to their cause and nature or concerning the means of controlling them that no leaflets have been issued. Others, again, are not of sufficient importance in this country to necessitate the publication of special leaflets.

Specimens of fruit tree and other plant diseases will, however, be examined and reported upon if forwarded to the Secretary. Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W.1. Such specimens should be carefully packed so that they may retain their freshness and remain undamaged during transit through the post.

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